Building Housing: The Allocative Efficiency of Creating New Cities Versus Expanding Existing Cities*

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Abstract

This paper explores the effect of two different types of land use policies on regional economies by using regional level data of South Korea. We analyze the effect of conventional land-use restrictions in existing cities as well as the effect of unique land-supply policies, motivated by the South Korean government's 2nd New Town Project which built new cities from the scratch, supplying 666,000 houses near Seoul Metropolitan Area (SMA). We estimate the effect of such policies on the aggregate and regional economies, considering both the efficiency gain from the resource reallocation and externalities from regional decline. If the government introduces tighter land-use restrictions in SMA and relaxes land-use restrictions in other regions, regional population will more evenly distribute at the cost of aggregate GDP loss and universal housing price increases. Our back-of-the-envelope calculation indicates that the 2nd New Town Project was cost effective as it permanently increased steady state real aggregate GDP flow by 0.4%, for the one-time cost amounting 4.05% of GDP. It however exacerbated regional decline by decreasing overall rural population share by 4%.

Keywords: Land regulation, Regional decline, Population distribution, Housing price distribution, Productivity growth, Migration, Spatial general equilibrium
JEL Classification: E24, E3, E6, R52, R11, R12, R14, J11

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1 Introduction

Recent skyrocketing house prices in the superstar cities such as Los Angeles and New York have been decorating the newspapers. At the same time, unlike before, labor incomes of those productive cities have been much higher than those of other cities, showing no patterns of convergence as noted by Ganong and Shoag (2017). Many economists believe that this pattern implies the misallocation of labors due to frictions caused by the housing market. Though Los Angeles and New York have higher labor productivities, enticing workers to move there, high house prices prevent those workers from moving. Recent research has estimated that the lost productivity in the US due to this misallocation is huge(Herkenhoff, Ohanian and Prescott, 2018; Hsieh and Moretti, 2019).

Flip side of the coin named misallocation is a regional decline.[1] As productive cities absorb economic resources, cities with low productivities lose most of their resources. People leave low productivity cities and city gets abandonded. This implies that the more reallocation means more regional decline. In the European Union (EU), Iammarino, Rodriguez-Pose and Storper (2019) showed that high income regions had population growth around 10% from 2000 to 2014, attracting individuals from low-income regions, which lost 2% of the population. Regional decline cannot be understood purely as a healthy resource reallocation. Breinlich, Ottaviano and Temple (2014) points out the potential externalities that might happen as a result of the regional decline. Infrastructure and social overhead capital in the declining regions will be less well utilized, and the local tax base will erode. In addition, the influx of new people into growing cities requires additional, expensive, infrastructure. Most importantly, declining regions are likely to become low-trust, high-crime regions. These regional decline issues also effect political stability, as shown in the Brexit Referendum.

Studying this coin named as "misallocation" in the head and "regional decline" in the tail, researchers have emphasized the role of land use policies. Glaeser (2014) shows how the 1960 property rights revolution led to a less elastic housing supply resulting in skyrocketing house prices. In addition, Herkenhoff, Ohanian and Prescott (2018) (hereafter HOP) argue that California and New York are much more tightly regulated than Texas, and they interpret such land-use regulations as main drivers of the misallocation. While academic discussion is in progress, these issues have also been prominent in political discourse. For example, the Biden Administration's Housing Supply Action Plan states "Exclusionary land use and zoning policies constrain land use, artificially inflate prices, perpetuate historical patterns of segregation,

[1] Regional decline can be a form of a decline not only in terms of absolute or relative living standards but also in terms of absolute or relative population (Breinlich, Ottaviano and Temple 2014). The literature has proposed a broad range of explanations for regional decline: it could be a result of geographical sorting (Diamond 2016; Kaplan and Schulhofer-Wohl 2017), lack of local competition (Alder, Lagakos and Ohanian 2014) or misallocation (Hsieh and Moretti 2019), which partially stems from rising housing prices in higher-income regions (Ganong and Shoag 2017.)

keep workers in lower productivity regions, and limit economic growth."[2] On the ther hand, in 2019, the former UK prime minister Boris Johnson and Conservative Party articulated a policy agenda called "Levelling up", which aims to "reduce the imbalances, primarily economic, between areas." This type of intervention, in the UK or elsewhere, combines various land policies. [3]

We provide a comprehensive analysis on these issues by analyzing South Korea through the lens of the model from HOP. We analyze the effects of different types of land use policies on the economy's allocative efficiency. Throughout the paper, we use a broader definition of allocative efficiency. On top of efficient resource allocations in terms of the marginal cost and marginal benefit, we use "allocative efficiency" as a concept that also incorporates potential externalities from regional decline. Our analysis goes beyond aggregate productivity changes, following our broader definition, to account for regional decline in South Korea.

Our paper is different in several aspects compared to the previous research. Our first innovation comes from the scope of land-use policies we cover. The South Korea government has implemented different types of land-use policies. First, it implements conventional land use policies on how land can be used for construction such as floor area ratio, building coverage ratio, and height restrictions. It is usually the legal restriction on what types of buildings can be built on or legal restriction on physical shape of the building.[4] The South Korean government has dealt with excessive migration to the Seoul Metroplitan Area (SMA) by relaxing these policies in the SMA. (*Expanding Existing Cities*) From now on, we call a group of such land use policies as "Land-Use Restriction."

The South Korean government has also implemented unique land use policies we categorize as "Active Land Supply", following the terminology of "active labor market policies (ALMPs)". Here, by the word "Land Supply", we mean the supply of the usable land which has a well-equipped infrastructure such as roads, irrigation system, and electricity grid system. In a land without any infrastructure, it is hard to encourage any economic activity. We do not consider land without any infrastructure a production factor. We only consider usable land with enough infrastructure where the economic activity can readily happen as a production factor. Starting in the 1980s, South Korean government implemented several New Town Projects (NTP) near SMA. Via these projects, they converted land near SMA without any well-equipped infrastructure into land on which a city can be built. This infrastructure initiative included a new zoning system to provide appropriate infrastructure. Such New Town Projects can be understood as kinds of the active land supply policies. (*Building New*

[2] The White House (2022, May 16). President Biden Announces New Actions to Ease the Burden of Housing Costs [Press release]. Retrieved from https://www.whitehouse.gov/briefing-room/statements-releases/2022/05/16/president-biden-announces-new-actions-to-ease-the-burden-of-housing-costs/

[3] *Levelling Up the United Kingdom*, Leveling up White Paper, CP 604, HM Government, Feb 2022. https://www.gov.uk/government/publications/levelling-up-the-united-kingdom

[4] In South Korea, local land-use restrictions are determined by regional authorities, while there are uniform legal boundaries in place, resulting in considerable variation across regions.

Cities.) For instance, the 2nd NTP in early 2000s provided $139.0km^2$ of usable land and 666,000 housing units nearby SMA.

South Korea's diverse land policies give us a reasonable case study for examining how different types of land policy affects regional economies. We study the effects of these two different types of land-use policies by using a structural model in HOP. We first estimate the overall level of land-use restrictions over time and across regions. We then perform a cost-benefit analysis of the 2nd NTP, and check how the active land-supply policy affected allocative efficiency in regional economics. To that end, we incorporate detailed administrative data from the 2nd NTP. Though many studies have examined the role of land use restrictions, this is the first paper that studies the implications of active land supply policies on allocative efficiency and regional economies.

Our second innovation is clearer identification on the effect of land use policies on regional resource allocations. South Korea is geographically small and its sub-regions are very homogeneous compared to other large economies, such as the US and the EU. South Korea's small size means it has low trading costs and low migration costs. All of the sub-regions in Korea share the same legal and cultural backgrounds. These two characteristics allow us to clearly observe the effects of land policies that are heterogeneously applied to the regions.

South Korea has experienced dramatic resource reallocation across regions. In 1970, only 34% of the total population lived in SMA. However, now its share is over 50%. House prices in SMA and the rest of South Korea have also rapidly diverged, implying that rural South Koreans have experienced a decline in their relative quality of life.

By using the region level data of South Korea from 2002 to 2019, we estimate the regional productivities, amenities, and land-use restriction levels by using the structural model. We find that the model-implied regional land price distributions matches the data quite well, and the model-inferred land-use restrictions are highly correlated with the observed legal regulations such as floor area ratio and building coverage ratio. Our calibration results indicate that Seoul has the highest TFP but is the least restrictive in terms of land-use restriction. We interpret this result as the South Korean government's choice to stabilize the Seoul Metropolitan housing market. In contrast, our estimates suggest that rural areas have heavy land-use restrictions compared to SMA.

We leverage the model and calibration results to analyze the impact of land-use restriction adjustments and active land supply on regional output, population distribution, housing prices distribution, and aggregate productivity. Through a set of counterfactual experiments, we examine the effect of changing land-use restrictions in the SMA while keeping the national usable land stock fixed. This mimics a policy suggestion from the public arena calling for stringent regulation in the SMA to alleviate regional decline. Our findings indicate that tightening land-use restrictions in the SMA by 15% could lead to a significant increase of population in rural regions, but at the cost of a universal increase in housing prices and a

1.4% decrease in aggregate output.

The second set of experiments focuses on the impact of actual land supply on economic outcomes. To establish a benchmark, we evaluate the 2nd New Town Project of South Korea, a significant land supply initiative in the SMA. Our findings show that the policy increased aggregate output by 0.4%. Given its cost of 4.05% of GDP at the time of implementation, we conclude that the NTP was a net positive for the economy based on a back-of-the-envelope calculation. The relaxed land-use restrictions in the SMA and New Towns also led to lower housing prices across all regions by attracting more people to these areas. However, our analysis suggests that the economic outcomes could have been better if the NTP had been implemented in non-SMA areas. In the "worst" case scenario, where all the NTP land was taken from the SMA and uniformly redistributed to Rural regions, the aggregate output would still have been 0.1% higher than the SMA baseline, and population concentration in the SMA would have been reduced and housing prices would have been lower across all regions. It is important to note that these results are based on a basic neoclassical model that does not account for agglomeration or skill heterogeneity, and should therefore be viewed as a baseline analysis and a call for further comprehensive analysis.

Our paper proceeds in following way. Section 2 places our paper within the literature and outlines its contribution. Section 3 provides an overview of the regional economies in South Korea, including a discussion of the ongoing debates surrounding land-use policy. Section 4 presents our model, and calibrates it using Korean data to estimate region-specific parameters of productivity, amenities, and land-use restrictions. We validate our model in this section using observed land prices and land-use restrictions. Section 5 conducts a set of land-policy experiments. Section 6 concludes, discussing the limitations of our analysis and potential directions for future research.

2 Literature Review

This paper is related to several veins of spatial-macro general equilibrium analysis. First, It falls within the realm of spatial policy literature that focuses on the effect of land-use regulation. The main focus of most research in this field is on understanding the impact of land-use restrictions on aggregate productivity. Land-use restrictions are viewed as a cause of slower growth via spatial misallocation with declined regional mobility, as demonstrated by Glaeser (2014), Furman (2015), and Hsieh and Moretti (2019). In this paper, we not only study the effect of conventional land-use restriction policies but also analyze the effect of active land supply policies on aggregate productivity through the lens of a structural model. While most related papers assume that the government determines how land can be used while its supply is constant (Herkenhoff, Ohanian and Prescott, 2018; Hsieh and Moretti, 2019), we consider increases in land stock due to active land-supply policies by the government. Land stock refers to land with appropriate infrastructure suitable for regular economic activities. While these policies may be similar to relaxing land-use restrictions in theory, the active land supply policies are considered an independent alternative in the public arena. Also, such policies can be better measured via their costs, area supplied, and location. To the best of our knowledge, there is no prior research that has used a structural model to analyze the impact of active land supply policy. We use our framework to evaluate the efficacy of South Korea's 2nd New Town Project, adding a new dimension to the land policy literature. The results of our study have implications for other countries that are using land policy to address regional decline, such as the UK.

Another challenge in the literature is measurement of land-use restrictions over time across regions. There have been several attempts to construct a systematic metric from regulation-related survey, beginning with the work of Gyourko, Saiz and Summers (2008), which was recently followed by Gyourko, Hartley and Krimmel (2021). Another approach is modeling an economic framework that maps more generic economic variables to a metric of land-use restriction. In recent work, HOP develop a spatial general equilibrium model to construct a time series estimate of residential land-use regulations for US states. Babalievsky et al. (2021) identify land-use restrictions on commercial properties from tax information, utilizing the near-universe of U.S. commercial property tax records. This paper adds an international dimension to the existing literature by providing the first estimates of land-use restrictions in South Korea. We validate the reliability of the model-based approach by leveraging South Korean data on observed land prices and land-use restrictions, such as floor area ratio or building coverage ratio.

The effects of land policies are studied for various outcomes other than aggregate productivity as well. Lindsay (2022) study the effect of land-use restrictions on welfare of households in different age and education groups in the US. Colas and Morehouse (2022) studies the relationship between land-use restrictions and environmental costs, arguing that relaxing land-use restriction in environmentally friendly cities will reduce carbon emissions. Moreover, Dachis and Thivierge (2018) studies the effect of land-use restriction on construction costs in Canada, while Cun and Pesaran (2021) studies the impacts of land-use restriction on internal migration, wages, and housing price to analyze spatial spillover effects. Our paper connects land policies to the regional decline literature by examining the relationship between land policies and the distribution of population and housing prices across regions. We view land policy not only as a possible contributor to population concentration and high housing prices, but also as a potential solution to these issues.

Regional decline has been a prevalent problem in many countries and a topic of significant interest in academic literature. Recently, in the US, the rise of super-star cities drastically contrasted with the fall of the rust-belt has prompted many researchers to study the determinants of regional growth and regional decline as noted in Desmet and Rossi-Hansberg (2014), Ganong and Shoag (2017), and Moretti (2013). While economists tend to interpret this process as a market driven reallocation, the public demand policy interventions to protect, or revive, regions with declining economies. Instead of taking a stance on regional decline as either a natural process or a problem in need of resolution, our study tries to analyze allocative efficiency in a broader sense, considering both aggregate productivity and potential externalities caused by land use policies.

3 Regional Economies in South Korea

South Korea has gone through significant resource reallocations, with the majority of economic resources moving to the country's capital, Seoul, and its surrounding areas. In order to comprehend this process and allocative efficiency in South Korea, it is crucial to overview its economic geography. This section begins by outlining the administrative divisions of the country.

3.1 Administrative Divisions

South Korea is comprised of seven Metropolitan Cities, eight Provinces (-do), and two special regions (Sejong and Jeju Special Self-Governing Province) in the highest geographical hierarchy as in Figure 1. Metropolitan Cities are legally independent entities, as they are not part of the Provinces. Designating certain regions as "Metropolitan Cities" is a political process. While there is a law defining requirements for each geographical unit, politics usually preceded laws.

Still, this administrative division provides a useful overview of the economic geography of South Korea. All seven Metropolitan Cities have a population of over 1 million and were once the major cities in their respective Provinces. Despite their legal independence, Metropolitan Cities are often still seen as representative of the Province they are located in. As a result, we classify Metropolitan Cities as urban areas with high population density and consider Provinces to encompass the remaining rural areas.

There are two special regions, Sejong and Jeju Special Self-Governing Provinces. These regions are considered separate and independent due to their specialized functions as a government and public administration cluster (like Washington D.C.) or large islands, rather than economic factors. Considering this, we exclude Sejong and Jeju from our analysis of regional decline.

3.2 Population Distribution

We start with showing how the regional population distribution has evolved in South Korea over time. Table 1 shows the population in each administrative region in 2020.

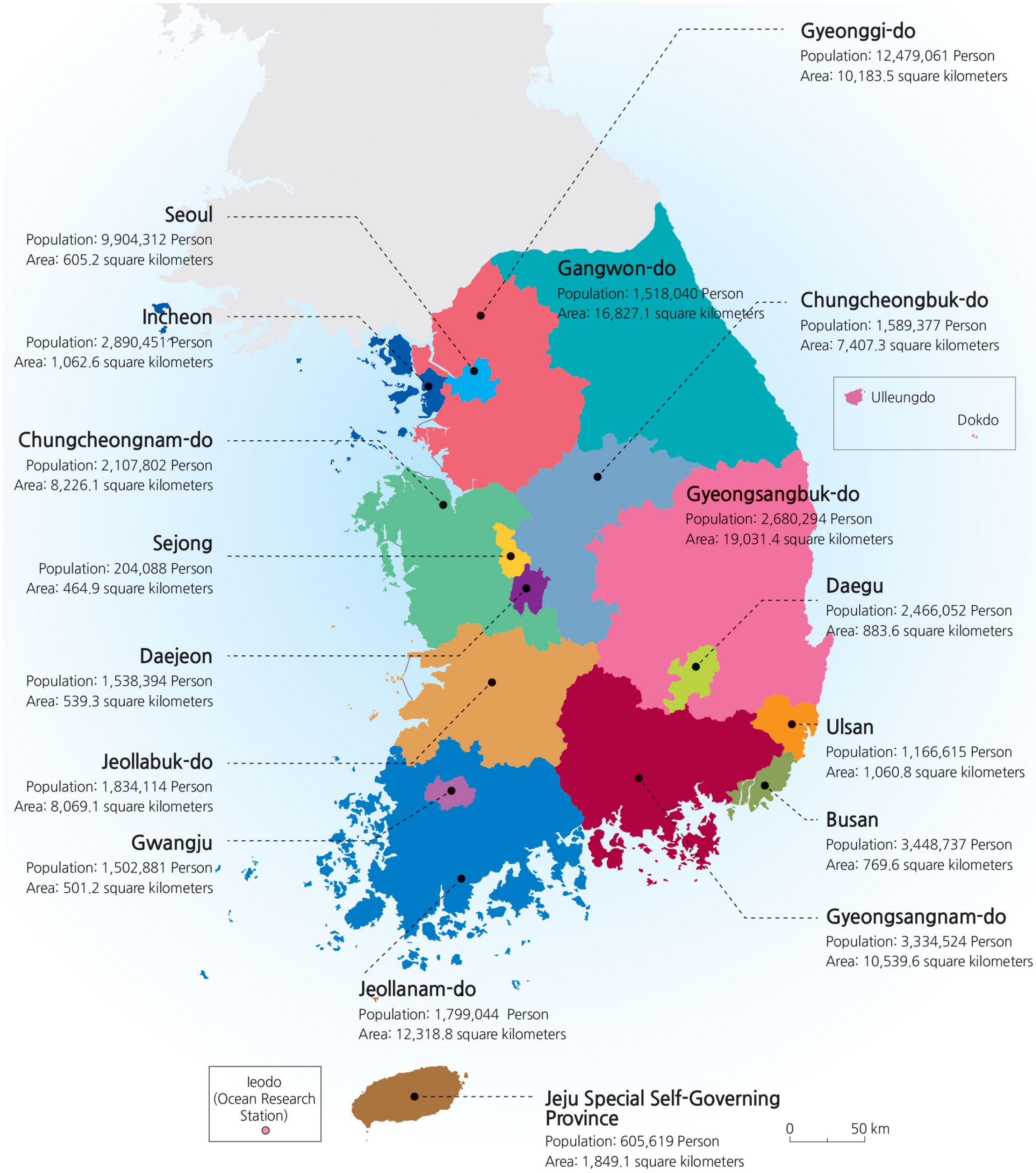


Figure 1: Administrative Division in South Korea (KNGII)

Seoul Metropolitan City and Gyeonggi Province, which is near Seoul, have the largest populations. Because Incheon Metropolitan City is close to Seoul Metropolitan City, we group these three regions as Seoul Metropolitan Area (SMA). In 1970, only 34% of the total population lived in Seoul Metropolitan Area. However, now its share is over 50%. On top of the SMA, we use two other regional classifications: Metro and Rural. Each corresponds to a group

Table 1: The Regional Population Distribution

Category	Region Name	Population Millions	%
A. Administrative Divisions			
Metropolitan City	Seoul	9.5	(18.4)
	Incheon	2.9	(5.7)
	Busan	3.4	(6.5)
	Daegu	2.4	(4.6)
	Gwangju	1.4	(2.8)
	Daejeon	1.5	(2.8)
	Ulsan	1.1	(2.2)
Province (-do)	Gyeonggi-do	13.6	(26.3)
	Gangwon-do	1.5	(3.0)
	Chungcheongbuk-do	1.6	(3.1)
	Chungcheongnam-do	2.1	(4.1)
	Jeollabuk-do	1.8	(3.5)
	Jeollanam-do	1.8	(3.5)
	Gyeongsangbuk-do	2.6	(5.1)
	Gyeongsangnam-do	3.3	(6.4)
Special Self Governing City	Sejong	0.4	(0.7)
Special Self Governing Province	Jeju	0.7	(1.3)
Total		51.6	(100.0)
B. Upper-level Divisions in the Analysis			
Seoul Metropolitan Area (SMA)	Seoul, Incheon, Gyeonggi-do	26.0	(50.4)
Metro	Busan, Daegu, Gwangju, Daejeon, Ulsan	9.8	(18.9)
Rural	All Provinces except Gyeonggi-do	14.8	(28.7)
Excluded	Sejong, Jeju	1.0	(2.0)

of Metropolitan cities and Provinces, except the three SMA regions. (Table 1) The upper-level divisions are analogous to the U.S. Census Regions in that the delineation is for the purposes of statistical analysis and presentation, not for administration.

Figure 2 shows the regional distribution of energy consumption in residential buildings in 2019 in the finer administrative division levels. Populations are concentrated in Seoul and near Seoul areas (Gyeonggi and Incheon) where the residential building energy consumption is significantly concentrated. On the other hand, in most of the Province areas, the energy consumption from residential building in each division is low, which means that the population is spread over larger regions. Most of the regions with high energy consumption coincide with the Metropolitan Cities' locations.

Now we present time trends in population distribution. Starting from 1970, Seoul Metropolitan Area and other Metropolitan Cities showed a dramatic increase in the population level, while the Provinces lost their populations. However, starting from 2000, even other Metropolitan Cities populations stopped increasing while Seoul Metropolitan Area kept absorbing the population. This population influx into SMA was driven by young people, which increased the relative average age of other region to Seoul Metropolitan Area. The fact that most Provinces are losing their populations and getting older has become a national concern because of potential negative externalities such as political instability and dramatic decrease of quality of life for residents.

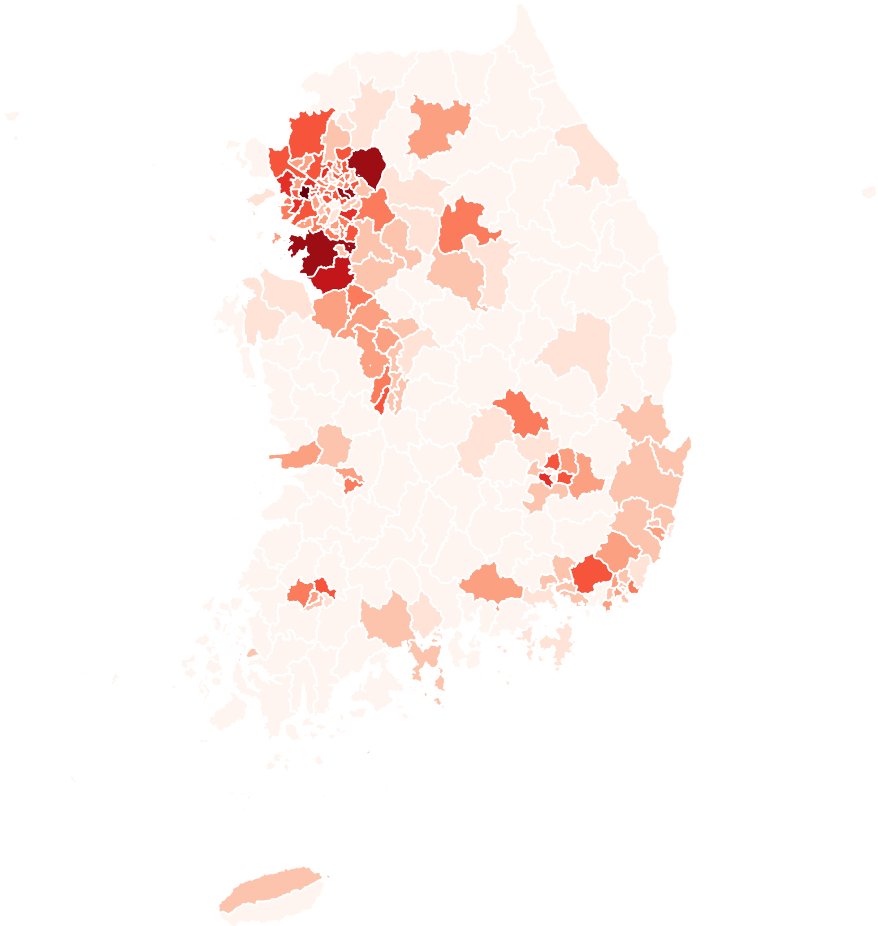


Figure 2: Residential Energy Consumption in South Korea

3.3 Regional GDP

Migration from non-SMA to SMA has exacerbated the difference between SMA and other regions. Figure 4 shows how this pattern has evolved. Most regions have seen their GDP per capita fall relative to Seoul. Even in the Ulsan Metropolitan City, which is filled with exporting factories, GDP per capita has fallen relative to Seoul. This pattern implies that Seoul's economic significance in South Korea is getting larger, which may come from the agglomeration effect.

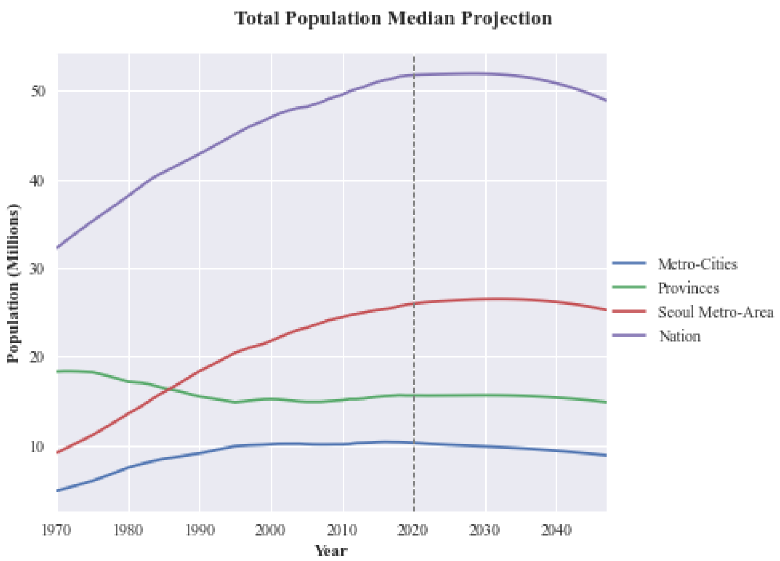


Figure 3: Population Distribution

3.4 Housing Price Distribution

What naturally follows is house price divergence. Given the limited land, as more population concentrates in Seoul Metropolitan Area while other regions' economies do not grow as much as Seoul, housing prices in Seoul have increased relative to other regions. In addition, although we cannot see the house price growth in Gyeonggi Province, in some of the subregions in Gyeonggi Province house prices are comparable to Seoul Metropolitan City. Figure 5 shows how housing prices have evolved over time. All regions show falling house prices relative to Seoul. On average, all regions' house prices relative to Seoul have been halved from 1986 to 2019. This change in house prices has made it considerably harder for workers to relocate to Seoul.

3.5 Land Policy and Regional Economies

This increasing concentration of economic resource in Seoul has been discussed as one of the most important problems that South Korea is facing. Many people discussed the potential role of land policies in such transitions. In this subsection, we discuss how these land policies are connected to both resource reallocation and regional decline.

3.5.1 Land-Use Restriction

Land-use restrictions are any constraints on how a specific piece of land can be used. Common types of land-use restrictions include floor area ratios, building coverage ratios, and height restrictions. These policies focus on the physical properties of the structures that can be built.

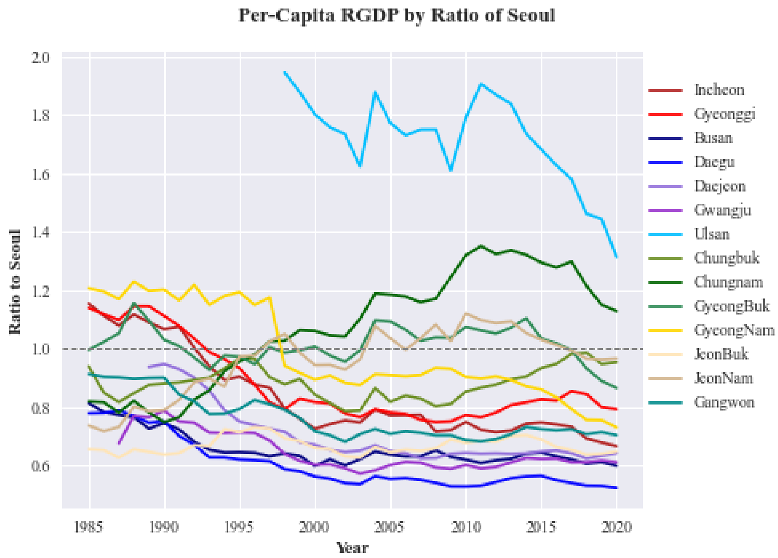


Figure 4: Relative real GDP per capita

Additionally, there may be restrictions on the types of buildings that can be constructed in certain areas. For example, in some regions, factories or garbage incinerators may not be allowed, and in extreme cases, no structures can be built at all.

In the latest presidential election in 2022, the two main candidates pledged to increase the floor area ratio in certain areas of Seoul to 500% by implementing new zoning types, according to Shin (2022). In addition, the elected President Yoon plans to increase the average floor area ratio from 200% to 300% in order to boost the supply of housing units Kim (2022).

These "expansionism" pledges have generated opposition due to concerns over insufficient infrastructure. The increase in housing unit supply is expected to result in a corresponding increase in population levels in the region, however, the capacity of current infrastructure is limited and unable to keep pace. Experts are also worried about the exacerbation of regional decline as more people are drawn to the Seoul Metropolitan Area, potentially expediting the migration of Rural populations to the city. Our subsequent analysis examines the impact of these land-use restrictions on population distribution, housing price distribution, regional output, and the aggregate output of South Korea.

3.5.2 Active Land Supply: New Town Project

In the late 1980s, to resolve the sky-rocketing housing prices and lack of housing supply near Seoul Metropolitan City, the South Korean government started to build new towns that are located within a 20 km perimeter around Seoul. This project was named as the "1st New Town Project." This project consists of building five new towns, Ilsan, Joongdong, Sanbon, Pyeongchon, and Bundang on lands which were rural area. This project supplied 292,000

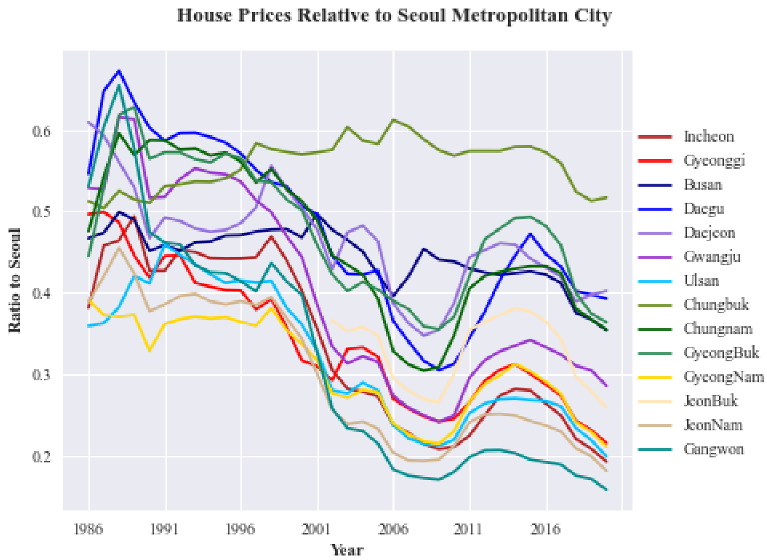


Figure 5: House Price Distribution

houses with appropriate infrastructure and transportation systems.

Many people consider this ‘1st New Town Project’ successful because it stabilized house prices and solved housing shortage problems. In the 1990s, experiencing another housing market boom, the South Korean government implemented the "2nd New Town Project," which provided 666,000 houses within the 40 km perimeter of Seoul. Most recently, the South Korean government is now planning the "3rd New Town Project" which will provide 178,000 more houses within the 10 km perimeter of Seoul.

This new town project is different from housing supply by private construction companies in the sense that the government plans the whole city with appropriate infrastructure. In other words, the government converts the unused land without any infrastructure into land on which cities can be built. This can be interpreted as active supply of urban lands.

Lands without any infrastructure such as roads, irrigation system and electricity supply will not be used by the private sector for housing nor production. By converting the land into the whole usable city, the government effectively supplies the land factor which can be used either the residential production or goods production. In this sense, the 1st, 2nd, and 3rd New Town Project can be interpreted as the government supplying land near SMA. Figure 6 shows how those lands were supplied.

On the one hand, proponents of these projects argue that migration to the new towns works as labor supply to the rapidly growing Seoul Metropolitan Area, which bolsters the economic growth of South Korea. On the other hand, many critics argued that these New Town Projects have exacerbated the regional decline by inducing people to move near Seoul Metropolitan Area. In addition, these government driven projects incur tremendous costs. The Second New

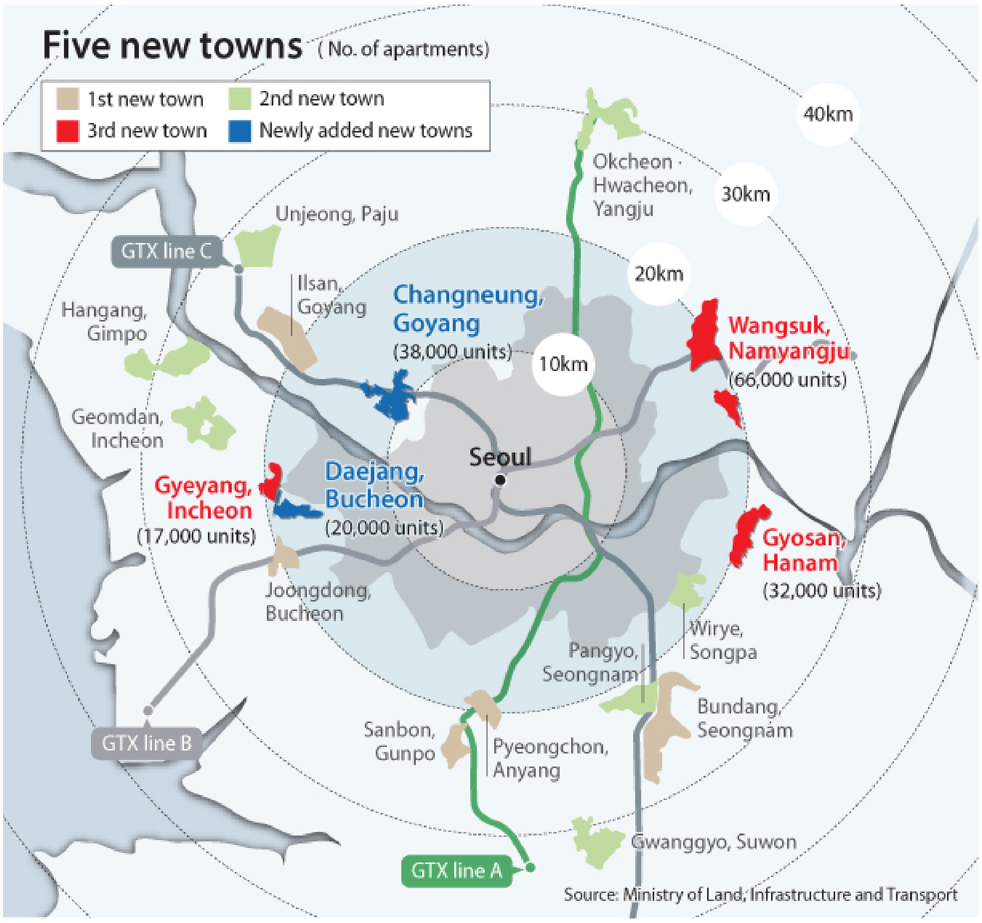


Figure 6: The 1st, 2nd, 3rd New Town Projects

Town Project cost 22 billion US dollars in 2004 US dollars. This was 4.05% of South Korea GDP in 2004. They argue that this fund could have been used to develop other cities in Provinces or near Non-Seoul Metropolitan Cities, which might have resolved regional decline.

In the later part of our paper, we try to provide the quantitative answer to this debate. By using HOP, we estimate the impact of the 2nd New Town City on regional population distribution, housing price distribution, and aggregate TFP. On top of that, we conduct the cost-benefit analysis of such a project. Lastly, we explore the effects of counterfactual policy building new cities in Provinces or near Non-Seoul Metropolitan Cities.

4 Model

In this section, we present our spatial growth model. Our model is based on HOP. Each region has an exogenous stock of land, and this land has two uses, housing production or consumption good production. As a land is a fixed factor at any time, following HOP, we represent the level of land-use restrictions (broadly defined including zoning, height restrictions, etc.) via the share of the land stock that can be utilized. These land-use restrictions are exogenous and time-varying, which we consider as policy variables.

4.1 Households

There are J regions, indexed by j. Time is indexed by t. There is one representative household that owns all the capital and stock of lands. In addition, they allocate workers under the constraint that housing should be properly provided to all those workers. The representative household solves the following maximization problem:

$$\max_{k^y_{jt}, k^h_{jt}, n_{jt}, x^h_{jt}, x^y_{jt}, h_{jt}, k_t} \sum_{t=0}^{\infty} \beta^t [u(c_t, n_t) + \sum_{j \in J} a_{jt} n_{jt}] \tag{1}$$

$$s.t. \quad c_t + i_t = \sum_{j \in J} p_{jt} h_{jt} = \sum_{j \in J} (w_{jt} n_{jt} + q_{jt} x_{jt} + \pi^y_{jt} + \pi^h_{jt}) + r_t k_t, \tag{2}$$

$$i_t = k_{t+1} - (1-\delta) k_t, \tag{3}$$

$$k_t = \sum_{j \in J} k_{jt} = \sum_{j \in J} k^y_{jt} + \sum_{j \in J} k^h_{jt}, \tag{4}$$

$$n_t = \sum_{j \in J} n_{jt}, \tag{5}$$

$$h_{jt} \geq n_{jt} \text{ for any } j, \tag{6}$$

$$x_{jt} = x^y_{jt} + x^h_{jt} \text{ for any } j. \tag{7}$$

We employ an additive separable utility $u(c_t, n_t) = \ln(c_t) - \frac{1}{1+\frac{1}{\gamma}} (\sum_j n_{jt})^{1+\frac{1}{\gamma}}$. This representative household chooses how many workers to allocate in each region n_{jt}, how many housing to purchase h_{jt} to provide them $n_{jt} = h_{jt}$, how much capital to invest in each region to final good sector and housing sector k^y_{jt}, k^h_{jt}, how much land to rent in each region to each sector x^y_{jt}, x^h_{jt}, and how much to save for the future production k_t.

From the specification of the problem, we know that consumption goods are traded across regions while housing, land, and labor are traded within each region, which gives the region-specific prices of housing and land, p_{jt}, q_{jt}, and wages w_{jt}.

4.2 Consumption Goods Production

In each region j, there is a representative firm producing a consumption good that will be a numeraire in this economy. Each representative firm uses labor n^y_{jt}, land x^y_{jt}, and capital k^y_{jt}. We consider a neoclassical production function $y_{jt} = A_{jt} F(k^y_{jt}, n^y_{jt}, x^y_{jt}) = A_{jt} (k^y_{jt})^{\theta} n^{\chi}_{jt} (\alpha^y_{jt} x^y_{jt})^{(1-\theta-\chi)}$. The land-regulation parameter α^y_{jt} governs the share of rented lands that can be used for consumption good production. Lower α^y_{jt} indicates tighter land-use restriction allowing firms to use very small portion of rented land for production. Consequently, a consumption good producing firm in region j solves:

$$\pi^y_{jt} = \max_{k^y_{jt}, n_{jt}, x^y_{jt}} A_{jt}(k^y_{jt})^\theta n^\chi_{jt}(\alpha^y_{jt}x^y_{jt})^{(1-\theta-\chi)} - r_t k^y_{jt} - w_t n_{jt} - q_{jt}x^y_{jt}. \tag{8}$$

4.3 Housing Production

Housing units are produced using capital and land only, while having separate land-use restriction parameter α^h_{jt},

$$\pi^h_{jt} = \max_{k^h_{jt}, x^h_{jt}} \quad p_{jt}(k^h_{jt})^\zeta(\alpha^h_{jt}x^h_{jt})^{1-\zeta} - r_t k^h_{jt} - q_{jt}x^h_{jt}. \tag{9}$$

4.4 Equilibrium

A competitive equilibrium consists of the following. Given the exogenous land stock in each region $[x_j]^J_{j=1}$, total factor productivity $[A_j]^J_{j=1}$, amenities $[a_j]^J_{j=1}$, and the sequence of land-use regulation policies $[\alpha^y_{jt}, \alpha^h_{jt}]^\infty_{t=0}$ for each region j,

- Optimal policy rules: $[n_{jt}, h_{jt}, x^h_{jt}, k^h_{jt}, k^y_{jt}, k_{t+1}, c_t]^\infty_{t=0}$
- Prices: $[w_{jt}, r_t, q_{jt}, p_{jt}]^\infty_t = 0$

which clears every market and solve representative households' optimization problem.

4.5 Key Spatial Equilibrium Condition

The economic environment presented above implies several important trade-offs. First,the representative household wants to allocate workers to a region with high productivity A_{jt} or amenity a_{jt}. However, given the fixed land supply, allocating all workers to such a region would not be affordable due to soaring housing prices. The following first-order condition formulates the intuition:

$$w_{jt}u_{c,t} + a_{jt} = -u_{n,jt} - p_{jt}u_{c,t}. \tag{10}$$

The left hand side of Equation (10) is the benefit of allocating an additional worker to region j. The worker earns w_{jt}, which delivers the marginal utility of $w_{jt}u_{ct}$. Being in j delivers its amenity a_{jt} as well. The right hand side is a sum of the labor disutility and oppotunity cost of forgone consumption due to housing. In the end, Equation (10) works as a key spatial equilibrium condition such that a worker cannot merely relocate to chase higher w and a combinations. Given the region specific productivities and amenities, house price and population distribution across regions will be determined following (10).

4.6 Identification and Data

We follow HOP to estimate the land-use restrictions, amenities, and TFP from the optimal allocation conditions of representative households. We assume symmetric restrictions on land-use $\alpha^h = \alpha^y$, additive amenities, and Cobb-Douglas production function which allows us to come up with identification equations about the land-use restrictions, amenities, and TFP. Those equations effectively connect the data to the parameters of interests $(\alpha_{jt}, A_{jt}, a_{jt}.)$ We solve for parameters $(\alpha_{jt}, A_{jt}, a_{jt}.)$ that allows the model to perfectly match the actual regional level data on house price, wage, and population distributions.

We collected Korean regional level data for the period from 2002 to 2019. Every variable is normalized by the total population of the country. We use the Economically Active Population Survey from Statistics Korea. It has information on population and labor dynamics. We use aggregate population older than 15 from the survey as total population, and use it to normalize every variable. In addition, from the same survey, we collect the number of regional employees for each region in each year for n_{jt}. For y_{jt}, we used the regional level Real GDP from Regional Income Survey by Statistics Korea. For real house prices p_{jt}, we extract the regional all-type average nominal house price in 2015 from Korea Real Estate Board. Then, by using the regional growth rate of nominal house price indices again from Korea Real Estate Board, we construct nominal average housing prices level from 2002 to 2019. After that, by using CPI, we construct the regional real house prices used in p_{jt}. All of these are comparable to the counterparts used in HOP.

Regarding the data for land x_{jt} as production inputs, there is a small but important difference between the data that we used here and the data used in HOP. HOP multiplied a share of urban land from the Census with the total available land acreage by state from the USDA-ERS. They calculated x_{jt} by dividing available land acreage by total population in thousands. Though we matched our data in scale as acre per hundred people as in HOP, our land data is the land acrage available for legally building residential and commercial buildings. Since South Korea is a geographically small country, in every region, we have a detailed and precise data regarding the land acres. Because there is a slight difference between the land data definition between HOP (urban land share) and ours (land legally designated for residential and commercial buildings), it is hard to directly compare the numbers from these two papers. However, our data has more direct implications in that our x_{jt} is literally the land that can be used for residential building and commercial activities. In addition, this is also directly related to the land that is supplied by the government in multiple New Town Projects.

4.7 Calibration

We use parameter values based on Korean data when there is an available value; otherwise we follow the literature. We set β as 0.9603 to match the average 10-Year Treasury yield between 2002 and 2018. In addition, we set depreciation rate δ as 0.03 which has been used in numerous Korean economy general equilibrium model including Bae (2013) or Song (2014). For the Frisch labor supply elasticity γ, we use 0.96 based on the estimates of Moon and Song (2016).

Moving toward the production function parameters, following HOP, we use 0.05 from Ákos Valentinyi and Herrendorf (2008) for the land income share of final goods production since there is no comparable estimates in South Korea. For the remaining labor income share χ, we use 0.647 while using 0.303 for capital income share θ to match the average labor income share in South Korea from 2002 and 2019.

The most difficult parameter to calibrate is $(1 - \xi)$ the land input share in housing production function. South Korea is mountainous and hilly compared to the US. In addition, its total land acreage is much more smaller than the US even relative to the total populations. The preferred housing arrangement is apartment in South Korea, unlike in the United States. This makes us believe that using the U.S. parameter from HOP is not suitable. Instead, we decided to pick the parameter value that best matches the land price data. The model is able to predict regional land prices given the land stock x, housing prices p, and population n. We picked the land share that minimizes the distance between the predicted and observed land prices.[5] We obtained 0.78, which is substantially different from the U.S. counterpart used by HOP, 0.38.

For the target land prices to match, we bring a novel dataset of South Korea. The South Korean government provides the details of every land transaction since 2006. Consequently, we collected all land transactions in every region in 2010. Then, we calculate, for every transaction, the land price per m^2 only for the lands where it is legal to built residential, commercial, or factory buildings.[6] Then, based on those prices per m^2, we calculate the 2010 average land price for every region. We calculate the nominal land price growth rate by using the nominal land price index from Korea Real Estate Board for each region over time. By combining these nominal land prices per m^2 and nominal land price growth rates, we construct the land prices across years for each region. Lastly, we calculate the real house price level per m^2 for every region using CPI.

We close this section by reporting the model fit in terms of land prices. Figure 7 compares the model-predicted and observed land prices. The model matches the land price data pretty well, even without any normalization. The worst prediction is on the southeast of the plot, where the model is underestimating land prices. The four points are from Gyeonggi, the largest Province of the country. We attribute the bad prediction to the Province's significant internal heterogeneity. The northern half is near the Demilitarized Zone (DMZ) and relatively

[5] See Appendix A for details.

[6] We excluded land on mountains where any types of economic activity is hard to appear or land where it is legally prohibited to build any kinds of building for environmental conservation.

less developed. The southern half is much more developed: it hosts Samsung and SK Hynix, the industry-leading semiconductor firms. It also has Suwon, the largest city hosting more than 1.2 million people.[7]

The comparison is obviously not a validation exercise. However, the model performance should not be underrated as a single parameter $(1 - \xi)$ is able to target sixty data points, which cannot be more parsimonious. Moreover, since land price data is available, the comparison can serve for validation if $(1 - \xi)$ is given externally.

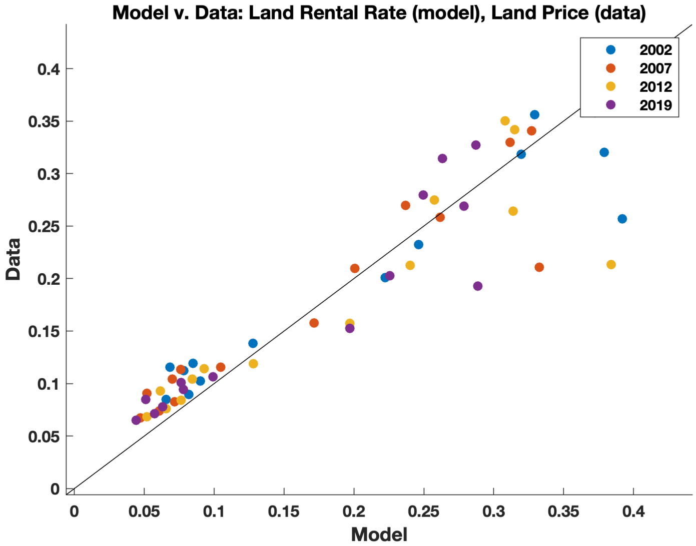


Figure 7: Model v. Data: Land Prices

4.8 Model Validation: Predicted vs. Observed Land-use Restrictions

In this subsection, before we proceed to the counterfactual analysis, we validate our model in terms of predictive power. By construction, our model perfectly matches the regional data on house prices, population distribution, and labor productivity like HOP. However, we proceed one more step in terms of model validation. We compare the model-inferred values of land-use restrictions to empirical analogues. [8] We compare our estimates with actual land-use restriction levels in South Korea by regions using detailed administrative data provided by the South Korean government.

[7] Had disaggregated data, it could have been better predicted, we conjecture.

[8] HOP compares the model-inferred TFP, land-use restrictions, amenities, and wages. We are unable to compare TFP and amenities because there are no such regional measures widely accepted in the literature, to our best knowledge. Our empirical analogy of land restrictions, taken directly from legal data, is different from HOP. On the other hand, land prices, the key allocation device, are not evaluated in HOP. While our land price comparison in Figure 7 is not a validation exercise, it still shows the model's capability. In this sense, our results complement the HOP ones.

Land-Regulation Predictions Our α is a usable share of urban land. There is no direct real-world counterpart for this measure. Still, popular land measurements such as Floor Area Ratio (FAR) and Building Coverage Ratio (BCR) are in the same spirit because those are fundamentally defined as a ratio with respect to the land area. We obtained area-weighted averages of the ratios at the regional level in 2019, the final steady-state year of the calibration. The model and data measures share the interpretation that any higher values imply lenient restrictions. We normalize both the model and data land-use restrictions to Seoul for ease of comparison.

Figure 8 shows that the model-inferred restrictions are positively correlated with both data measures. While the model is underestimating at face value, a simple linear regression shows that the correlations are surprisingly high. Table 2 reports $R^2 > 0.75$. For the BCR, in particular, the regression coefficient is nearly the unity, which means the model and data measures are nearly the same after adjusting for the constant. The FAR results echo the same message. This gives us confidence regarding the reliability of counterfactual analysis.

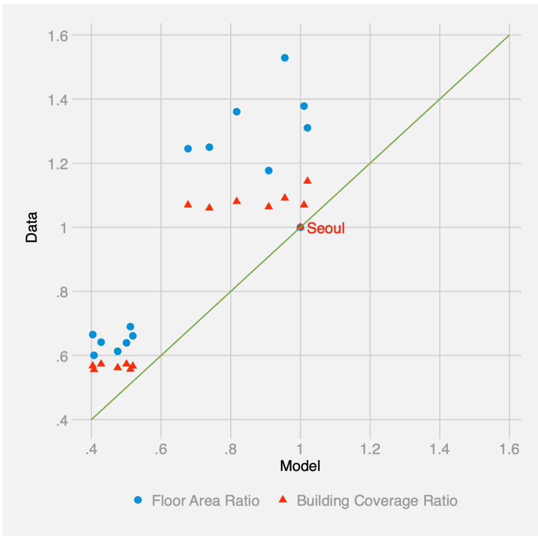


Figure 8: Land-use Restriction: Model v. Data (2019)

4.9 Model-inferred Parameters

We report the model-inferred TFP, land-use restrictions, and amenities in Figures 9, 10, and 11.

Total Factor Productivities Figure 9 shows that the Seoul region consistently exhibits the highest productivity across all time periods, with the gap between the least productive region, Incheon, almost 25%. In 2002, the regions were divided into two groups: Seoul and the rest. By 2019, the latter group was further subdivided into Gyeonggi-Rural and Incheon-Metro.

Table 2: Land-use Restriction: Model v. Data (2019)

	(1) Building Coverage Ratio	(2) Floor Area Ratio
Model	0.994***	1.253***
	(0.083)	(0.185)
Constant	0.148**	0.118
	(0.058)	(0.105)
N	15	15
R^2	0.831	0.760

All model and data measures are normalized with respect to Seoul.

This division may be attributed to the significant capital investment made by major exporting firms such as Samsung and SK Hynix in the Gyeonggi and Rural regions. Despite some fluctuations, the overall trend of productivity growth is upward.

(a) Level

(b) Relative to Seoul

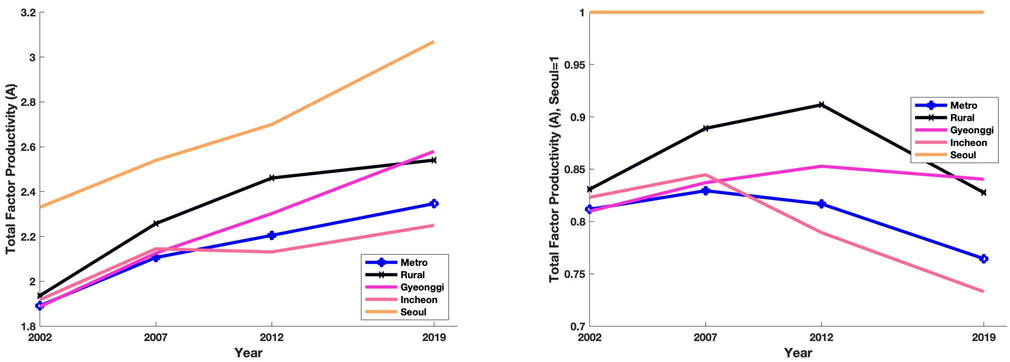


Figure 9: Total Factor Productivities

Land-Use Restrictions In Figure 10, the land-use restrictions remain relatively stable over time, both in terms of levels and ranks, with the exception of a slight decline in Metro. Small fluctuations in the Seoul Metropolitan Area coincide with the Great Recession and the government stimulus package. The restriction is relaxed between 2007 and 2012, and reversed since 2012.

It may seem counterintuitive that Seoul, with its hot housing market, has the least restrictive regulations in the country. However, this leniency is precisely because of the high demand for housing in the region. For example, Seoul has the highest floor area ratio and building coverage ratio. A comparison between the actual regulatory figures and the model-inferred restriction parameters can be found in Section 4.8. This is the opposite of California with tighter land-use restrictions studied in HOP. In some sense, we can argue that South Korea allowed more people to move into the SMA by relaxing the land-use regulation unlike California. By pushing agglomeration to such a great extent, the country could attain economic prosperity known as the Han River's Miracle, but it came with the cost of regional decline.

This gives us a lesson to the interpretation of our counterfactual experiments later. If such lenient land-use restrictions in Seoul are the consequence of the higher demand from many people while the tighter land-use regulation in rural area is the consequence of lower demand, our counterfactual analysis curbing the SMA land-use restrictions has more realistic implications than the counterfactual relaxing the land-use regulation in rural area, where the restrictions might not be binding.

(a) Level (b) Relative to Seoul

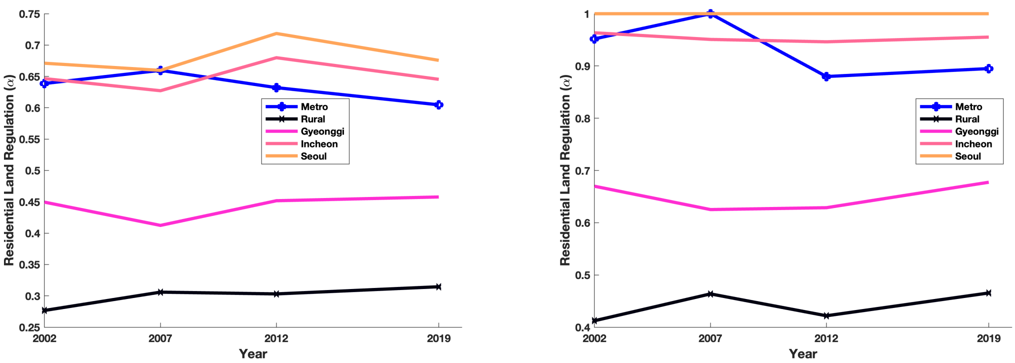


Figure 10: Land-use Restrictions

Amenities Amenities have converged over time, with the exception of Rural as described in Figure 11. In 2002, Seoul and Gyeonggi had the highest amenities, but there was a sizable decline by 2019. Incheon and Metro were in the middle-range group of amenities, but grew over twenty years. Rural, however, lagged behind with the lowest levels of amenities. Despite recent growth, the levels of amenities in Rural have not even reached their 2002 level.

The large drops observed in Panel (b) may be misleading. Panel (a) reveals that these drops are primarily driven by the growth of Seoul and Gyeonggi, rather than declines in the other regions. Additionally, the growth observed in 2007 was transitory. The main takeaway from Panel (b) is the convergence of amenities across regions, with Rural regions falling behind.

5 Counterfactual Experiments

In this section, we experiment with land policies and examine their potentials and limitations at the national and regional economy levels. The first set of experiments adjust land-use restrictions (α_j) and the second set of experiments adjust regional urban land stock (x_j) to emulate historical active land supply policies.

Throughout the analyses, our main outcomes of interest are aggregate and regional output

(a) Level (b) Relative to Seoul

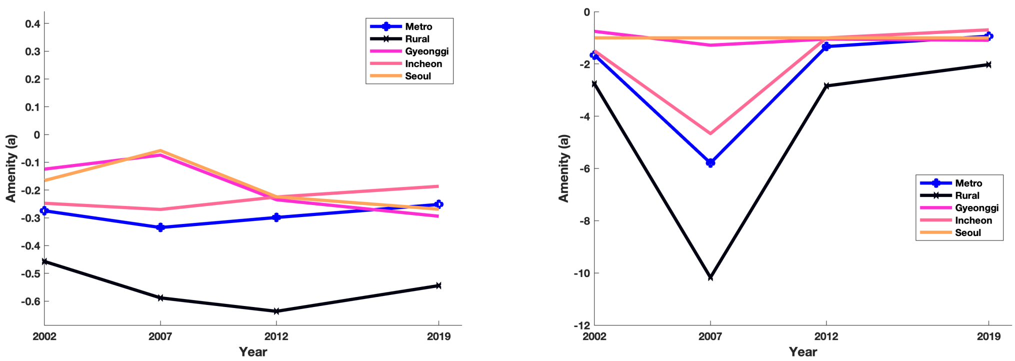


Figure 11: Amenities

per capita, and population and housing prices distribution across regions.

(a) TFP (Seoul = 1) (b) Amenities (Seoul = -1)

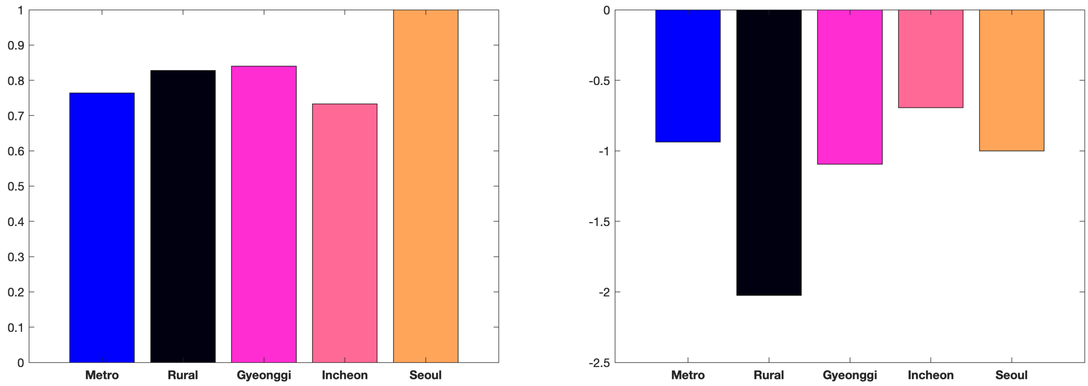


Figure 12: 2019 Regional Parameters

5.1 Expanding Existing Cities: Land-Use Restriction Experiments

We infer the region-defining fundamentals $(\alpha_{jt}, a_{jt}, A_{jt})$ using the model. The experiments on land-use restrictions manipulate the inferred α_{jt} to simulate a series of counterfactual scenarios that either regulate or deregulate certain regions to alter *usable* urban land stock $\alpha_{jt}x_{jt}$, keeping urban land stock x_{jt} constant. Figure 12 visualizes the parameters invariant across experiments, (a_{jt}, A_{jt}).

In order to make the experiments comparable, we keep the national stock of usable urban land $\overline{x} = \sum_j \alpha_j x_j$ fixed. For example, if we increase α_{SMA} by 15%, which implies 15% lenient regulation, we proportionally decrease it for all the other regions to balance the national land stock equation. This constraint is to quantify the direction and degree of misallocation due to land use regulation, rather than to add a layer of reality. If deregulating SMA (regulating the others) delivers a higher aggregate output then regulating SMA (deregulating the others), it indicates the former achieves more efficient allocation compared to the latter.

To set the stage, we take the 2019 model steady state and (de)regulate the Seoul Metropolitan Area by 15%. This provides the first quantification of the impact of land-use restrictions in the Korean economy. In other words, we effectively treat the country as a collection of two greater regions, the SMA and the rest of the country, in terms of policy changes.

We then add a simple heterogeneity to the experiment. In contrast to the SMA regulation experiment which deregulates all non-SMA regions uniformly, we deregulate Metro only, keeping Rural the same, then vice versa. Again, the national land stock remains fixed throughout these experiments. The goal of adding the heteogeneity is as follows. By taking regional heterogeneity seriously, it illustrates that the impact of land-use restriction changes on regional decline may starkly vary depending on which regions are more or less regulated.

Table 3 is a list of the land-use restriction experiments and the corresponding proportional adjustments in $\alpha_{j,2019}$. Table 4 summarizes the results of these experiments. We discuss the results in the following subsections.

Table 3: The Land-Use Restriction Experiments: Scale Adjustments in $\alpha_{j,2019}$

	SMA	Metro	Rural
(1) Baseline	1.00	1.00	1.00
(2) Dereg. SMA; Reg. others uniformly	1.15	0.91	0.91
(3) Reg. SMA; Dereg. others uniformly	0.85	1.09	1.09
(4) Reg. SMA; Dereg. Metro; Keep Rural	0.85	1.32	1.00
(5) Reg. SMA; Keep Metro; Dereg. Rural	0.85	1.00	1.13

Table 4: Land-use Restriction Experiments (Relative to the Baseline)

	(1) Baseline	(2) Dereg. SMA 15% Reg. All others	(3) Reg. SMA 15% Dereg. All others	(4) Reg. SMA 15% Dereg. Metro	(5) Reg. SMA 15% Dereg. Rural
A. Aggregate Measures					
Output	1	1.014	0.986	0.987	0.985
Consumption	1	1.012	0.989	0.990	0.989
Investment	1	1.014	0.986	0.987	0.986
B. Welfare Gains (Percentage Points)					
Total	0	1.638	-1.651	-1.301	-1.794
Contribution of Direct Utility (%)	0	0.598	0.575	0.845	0.494
Contribution of Amenity Access (%)	0	0.402	0.425	0.155	0.506

The aggregate measures are reported as a ratio to the baseline. The welfare gain is defined as a consumption equivalence. It means how many percentage points the per-period consumption should change to achieve the new level of aggregate utility, $100 \times [exp(U_{counterfactual} - U_{baseline}) - 1]$.

5.1.1 SMA (de)regulation with uniform treatment of Metro and Rural

Aggregate Output and Welfare Column 2 of Table 4 shows that the 15% deregulation of SMA increases the aggregate output per capita by 1.4% and welfare by 1.64%p. On the other hand, column 3 of Table 4 shows that the 15% regulation has the opposite effect. The aggregate output per capita and welfare drops by 1.4% and 1.65%p, respectively.[9] These results indicate that deregulating SMA yields a more efficient allocation than deregulating the other regions. The major driver of the output gain is labor and capital reallocation to higher TFP regions, the SMA. It also contributes to the welfare changes by letting workers access to amenities, especially for those who move from Rural to the other regions. The amenity access driven changes account for about 40% of the total welfare changes.

Employment Shares, Housing Prices and Regional Output Figure 13 shows that the regulation and deregulation experiments (2 and 3) deliver mirrored results for employment, housing prices, and regional output per capita. The deregulation-driven reallocation increases the SMA's employment shares by about 6%p in total. (Panel b) Gyeonggi and Seoul gain about 2.5%p while Incheon, which has the lowest TFP, gains barely about 1%p. (Figure 12) Both Metro and Rural lose workers, but Rural's loss is almost twice as large as than Metro's. The difference is driven by rural's lower amenity since the two have a similar TFP. Housing prices drop in all regions. (Panel d) It shows that the additional housing supply from the usable land supply dominates the housing demand in SMA. In Metro and Rural, the shrinking housing demand due to employment loss dominates the reduction in housing supply.

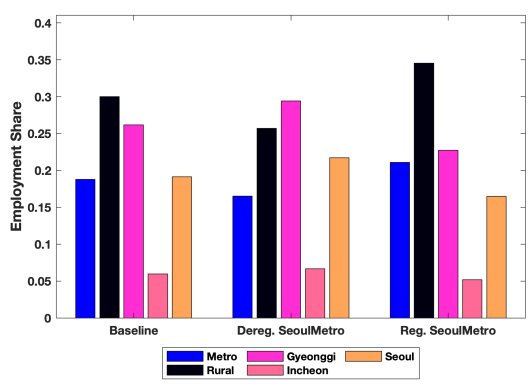
On the other hand, panel (e) and (f) show that the SMA deregulation widens spatial inequality via reallocation, which is another trade-off. All three SMA regions enjoy about a 12.5% increase in regional output per capita, while Metro and Rural undergo almost same loss. These results demonstrate the importance of considering regional characteristics when imposing land-use policy. Imposing the same level of land-use restriction to Metro and Rural imposes a larger toll on Rural in terms of employment loss. Strict land-use regulation on low TFP and amenities regions may exacerbate the regional decline faster than other regions. The SMA regulation moves the economy in exactly opposite direction, which is beneficial to Metro and Rural but inefficient at the aggregate level.

We put those numbers into the context of regional decline and national growth. The decline in regional employment shares and output per capita can be alleviated by regulating the SMAs and deregulating Metro and Rural. This approach comes with the cost of a 1.5% loss in aggregate output and a 2%–5% increase in housing prices throughout the country. While the stark tradeoff partly stems from the fixed national land stock $\overline{x}$, the remaining question is whether heterogeneous treatment of non-SMA regions under the national constraint could

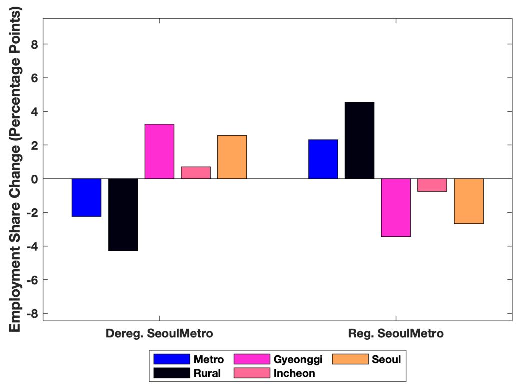
[9] The two experiments mirror each other. The 0.01%p difference between the welfare gain and loss stems from the concavity of the utility function.

do better by any means, given the same cost of regulating SMA.

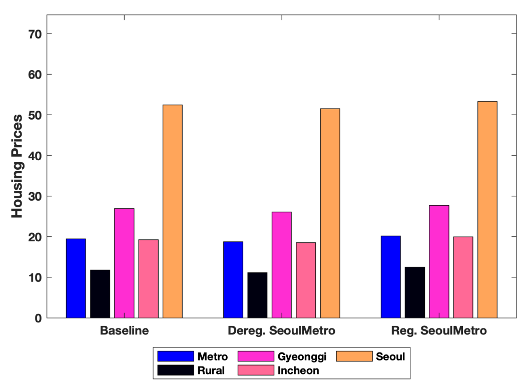
(a) Employment Shares, Level



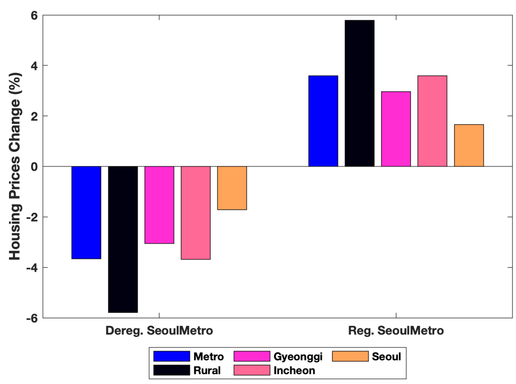
(b) Employment Shares, Changes



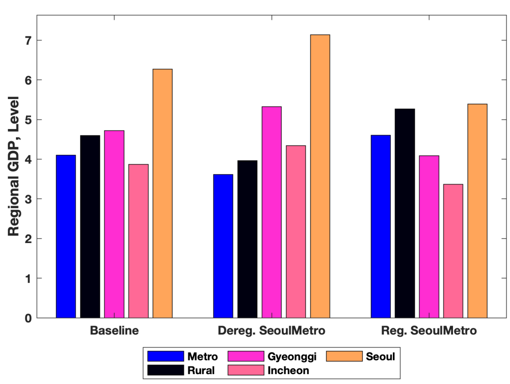
(c) Housing Prices, Level



(d) Housing Prices, Changes



(e) Regional Output per capita, level



(f) Regional Output per capita, changes

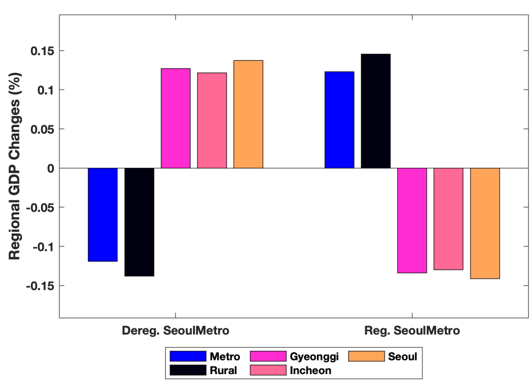


Figure 13: (De)regulating SMA with uniform treatment of Metro and Rural

5.1.2 SMA regulation with heterogeneous treatment of Metro and Rural

These experiments explore the direction and degree of misallocation between Metro and Rural, accepting the aggregate output and welfare deterioration due to the SMA regulation. Metro has to be deregulated by more than 30%, and Rural by 13%, to keep the national stock of usable land fixed (Table 3), which shows that Rural has a higher baseline usable land stock.

Aggregate Output and Welfare Columns 4 and 5 of Table 4 show that the output loss from regulating the SMA effectively remains the same as the uniform treatment case (Column 3). However, the welfare gains are more divergent. Deregulating Metro has the smallest welfare loss compared to the uniform case and deregulating Rural. The main channel is amenity differences across regions. Rural has the lowest amenity among the five groups, and the welfare loss due to amenity change is -0.91%p in the deregulating Rural experiment (Column 5). The influx of population into the Rural area suffers from the lower amenities.

The uniform case alleviates the loss by allocating some workers to Metro. The deregulating Metro further alleviates the loss by allocating most SMA-leaving workers to Metro. By doing so, welfare losses from each experiment due to amenity amounts to -0.70%p and -0.20%p, respectively, which are considerably smaller losses than from the Rural deregulation case. In terms of welfare loss, focusing on Metro outperforms the uniform deregulation, given the amenities.

Employment Shares, Housing Prices and Regional Output Figure 14 shows that the results are qualitatively similar with the uniform case: SMA loses employmet shares and regional output per capita and housing prices rise in all regions. But there are noticable differences as well. In panel (b), expanded regions have higher employment shares. Panel (d) shows that housing prices rise in all regions for both experiments. In the SMA, the decreasing housing supply, due to tightened land use regulation, dominates the shrinking demand. Metro and Rural experience the opposite shift. The demand side due to the incoming population dominates and lifts regional housing prices, regardless of whether usable land stocks increase or remain fixed. The housing price increases are higher if Rural is deregulated. Given that the labor reallocation governs housing demand and housing, panel (f) shows that non-SMA regions enjoy higher regional output per capita, by about 35% (expanded Metro) and 20% (expanded Rural).

The results indicate that any similar output changes may not necessarily come with similar welfare and population distribution changes. Moreover, such differences could be driven by regional amenities. Our results suggest that adjusting land-use restriction with no changes in amenities might be insufficient, even after the national land stock constraint is relaxed. First, in the long-run, a region with a low-amenity but lenient land-use restriction may fail to

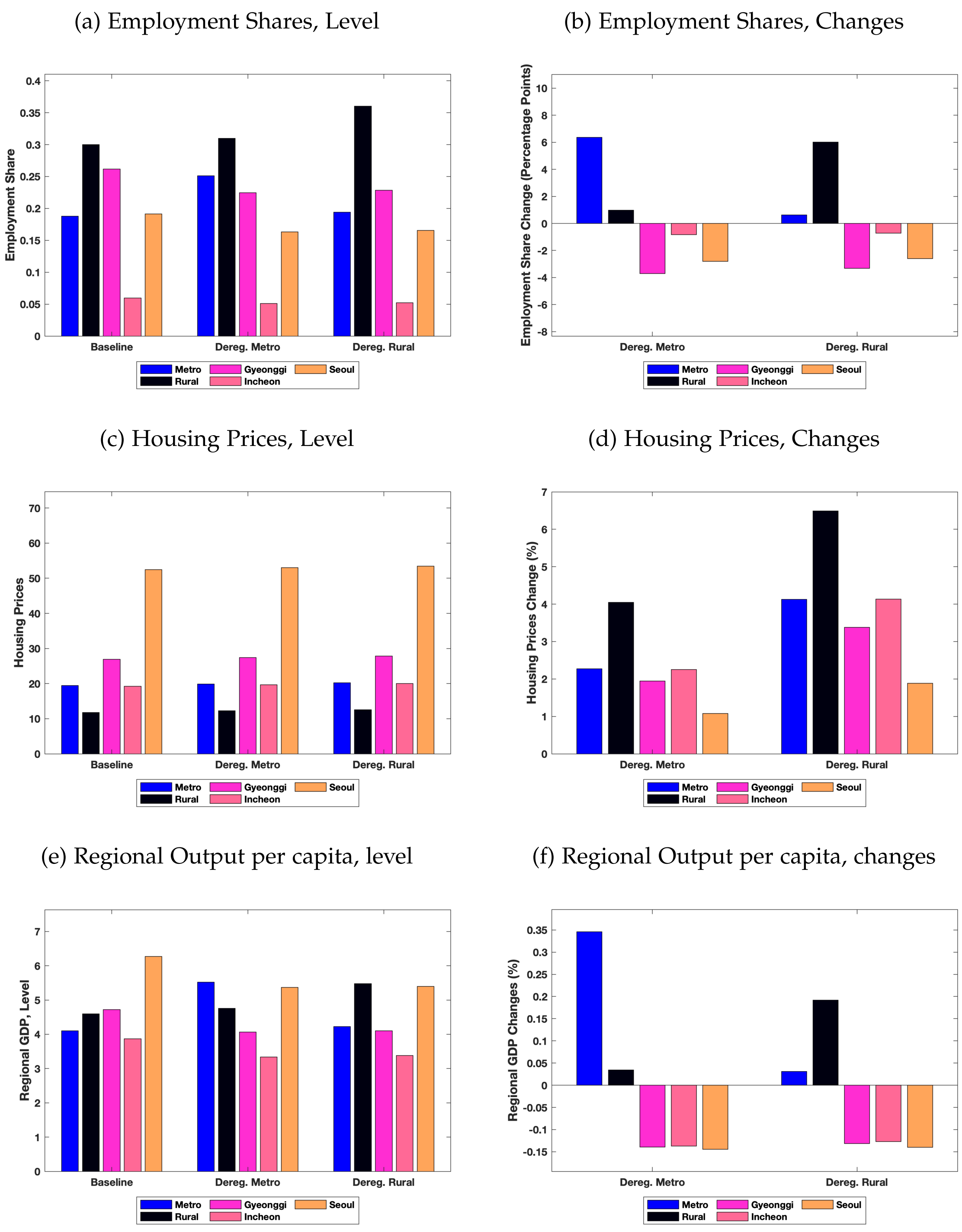


Figure 14: Regulating SMA, deregulating either Metro or Rural

induce population, although this mechanism is not explicitly operating in the model. Second, if α and a are negatively correlated, due to congestion cost for example, the welfare loss from population reallocation would be more pronounced and land-use restriction would be less effective.

Ulsan Metropolitan City, one of the Metro regions, fits this story well. It has the highest TFP but the lowest amenity in the country, which is in line with the real-world observation. While its regional income is top-notch, it is the smallest region among Metro, the city is not often considered a city can substantially grow by relaxing land-use regulations. This limitation leads us to consider the possibility of alternative policies such as active land supply, which can go beyond tweaking land-use regulation.

5.2 Creating New Cities: Active Land Supply Experiments

The active land supply experiments change the usable land stock of regions by changing x_j instead of α_j, and are constrained by the national land stock equation. Since the model defines usable land as a product of land-use restriction and urban land, i.e. $\alpha_j x_j$, in principle, any active land supply $\Delta x_j > 0$ can be replicated by an appropriate adjustment of α_j keeping x_j unchanged.

The active land supply experiments have rather an advantage of being more tightly connected to real-world policy. The New Town Project supplied urban land to a region, converting unused rural land into urban land. It gives us an observed Δx_j and the corresponding government-reported costs of development. Using this data, we can conduct a cost-benefit analysis of the NTP and quantify its regional consequences. Moreover, we can consider counterfactual policies such that the land is supplied to elsewhere, keeping the total costs of development constant. In other words, the active land use supply experiments are about where to spend budget and the land-use restriction ones are about where to adjust frictions. The two sets of experiments are subject to different constraints.

We first quantify the impact of the 2nd New Town Project, which serves as a benchmark of active land supply counterfactuals. To that end, we take the 2019 model steady state and reduce the land stock x by the NTP-supplied amount. The counterfactual losses are defined as the gains from NTP.

Given the benchmark, we simulate counterfactual economies where the NTP takes place outside of the SMA to answer our main question, whether land policies can defy regional decline. The first experiment ("leveling up the country") is to uniformly redistribute the land supplied by the 2nd NTP to the twelve non-SMA regions, keeping the amount of money spent. We first calculate the cost per acre in non-SMA regions using three non-SMA New Town Projects in order to address the fact that land prices are higher in the SMA on average. The cost per acre in the non-SMA area turns out to be around 67% of the 2nd NTP. Thus, the counterfactual land supply is (the 2nd NTP supply)/(0.67). We distribute this land to all non-SMA regions. [10]

The final two experiments push the question of the leveling up the country experiment further, in order to sharpen our points on regional decline, as we did in the land-use restriction experiments. We now distribute the counterfactual land supply unevenly across the country: land supply only to Metro ("NTP in Metro"), then only to Rural ("NTP in Rural"). Again, throughout the experiments, the 2nd-NTP supplied land stock are taken from the SMA. Table 5 is a list of the active land supply experiments and the corresponding Δx_j.

Table 5: Active Land Supply Experiments (Relative to the Baseline)

	SMA			Metro	Rural
	Seoul	Gyeonggi	Incheon		
(1) Baseline	-	-	-	-	-
(2) No 2nd New Town Project	-0.0006	-0.0207	-0.0027	-	-
	(-6.12)	(-4.23)	(-0.51)		
(3) Leveling up the Country	-0.0006	-0.0207	-0.0027	0.0003×5	0.0003×7
	(-6.12)	(-4.23)	(-0.51)	(3.51)	
(4) NTP in Metro	-0.0006	-0.0207	-0.0027	0.0072×5	-
	(-6.12)	(-4.23)	(-0.51)	(18.0)	-
(5) NTP in Rural	-0.0006	-0.0207	-0.0027	-	0.0051×7
	(-6.12)	(-4.23)	(-0.51)	-	(3.70)

The aggregate measures are reported as a ratio to the baseline. The welfare gain is defined as a consumption equivalence. It means how many percentage points the per-period consumption should change to achieve the new level of aggregate utility, $100 \times [exp(U_{counterfactual} - U_{baseline}) - 1]$.

5.2.1 No NTP and Leveling Up the Country

Aggregate Output and Welfare Column 2 of Table 6 reports that the No NTP economy would have 0.4% lower aggregate GDP, or the 2nd NTP increased the aggregate GDP by 0.4%. Since the model considers the steady-state, it is equivalent to $0.4 \times 20 = 8\%$ discounted sum of future output gains. Since the NTP-incurred the one-shot cost amounting 4.05% of GDP in 2004, the result justifies the NTP by showing its gain outweighed the cost in the long run by a factor of two, roughly speaking.[11] Welfare rises by similar percentage points, 4.95%p, and mostly from direct utility.

What if the NTP took place in the non-SMA regions, aiming to leveling up the country? Column 3 of Table 6 is our answer from the model. Compared to the 2nd NTP, the leveling up

[10] See Appendix C for more details.

[11] The 2nd New Town Project was implemented from 2004 and it's estimated spending was 3.6 trillion USD. In 2004, the country's GDP was 908.4 trillion KRW. Since GDP grows over time, if we change the base year, the spending to GDP ratio will fall. Our back-of-the-envelop calculation of the net gain thus works as an lower bound.

Table 6: Active Land Supply Experiments (Relative to the Baseline)

	(1) Baseline	(2) No NTP	(3) Levelling Up the Country	(4) NTP in Metro	(5) NTP in Rural
A. Aggregate Measures					
Output	1	0.996	1.002	1.004	1.001
Consumption	1	0.994	1.005	1.008	1.003
Investment	1	0.996	1.003	1.005	1.002
B. Welfare Gains (Percentage Points)					
Total	0	-0.495	0.342	0.581	0.168
Contribution of Direct Utility (%)	0	0.808	1.122	0.940	1.575
Contribution of Amenity Access (%)	0	0.192	-0.122	0.060	-0.575

The aggregate measures are reported as a ratio to the baseline. The welfare gain is defined as a consumption equivalence. It means how many percentage points the per-period consumption should change to achieve the new level of aggregate utility, $100 \times [exp(U_{counterfactual} - U_{baseline}) - 1]$.

approach increases 0.2%p higher GDP. It is 0.6% higher than the No NTP case. These results suggest that the Leveling Up strategy could be more efficient approach in that the marginal production of usable land declines faster in the 2nd NTP in the SMA. The welfare gain is also positive and driven by direct utility gain. It completely offsets the loss from lower amenities in the expanded non-SMA regions.

Employment Shares, Housing Prices and Regional Output The key reallocation mechanism in the active land supply experiments are the changes in marginal production of factors due to the additional usable land stock. Namely, higher land stock boosts both MPL and MPK. The magnitude of reallocation is smaller because the new land supply shifts up the national land stock, keeping non-policy regions' land stock unchanged, unlike the land-use restriction experiments.

Panel (b) of Figure 15 shows that changes in employment shares are smaller than the land-use regulation exercises. While the No NTP experiments take land stock from all SMAs, Gyeonggi, Incheon, and Seoul, Gyeonggi suffers the largest employment loss. While this pattern mechanically reflects that the 2nd NLP mostly took place in Gyeonggi, it also shows that the policy-induced reallocation of workers to Gyeonggi was mostly from Metro and Rural, rather than the other two SMA regions. Panel (d) shows that housing prices would have been higher by 2–4% if there was no NTP. The larger increases in Metro and Rural reflects housing demand decrease in those regions due to the NTP. Lastly, regional output per capita in panel (f) summarizes the message: the 2nd NTP catalyzed the growth of the SMA at the cost of decline of the non-SMA.

The alternative land supply scheme, "leveling up" suggests an another possibility. In panel (b), the policy induces a reallocation of workers to Metro from all other regions. While the reallocation is tiny compared to the other experiments, it still comes with lower housing prices in all regions as panel (d) illustrates. Panel (f) shows that, as a result, Metro's regional per capita income would have been slightly higher than the data. These estimates suggest that the Metro regions could have served as an engine of "regional revival."

The leveling up approach brings modest gains at the aggregate level and mitigates spatial concentration of population. The cost is insignificant even at the regional level. The results challenge a conventional notion of growth and (spatial) inequality tradeoff, rasing a question of whether a balanced development policy should have been implemented instead of NTP 20 years ago. However, these findings should be viewed as exploratory to examine the main question of regional decline and land policy. All the results are building on the estimated impact of the NTP, which may not be fully captured by the model framework. For instance, the absence of agglomeration forces in the current specification may underestimate the gains from the NTP in SMA. Thus, more concrete policy recommendations calls for a more comprehensive general equilibrium model that incorporates factors such as agglomeration and skill heterogeneity. Our current results, again, are to illustrate the potential of policy evaluation and prescription and the need for further research.

5.2.2 NTP in Metro, NTP in Rural

We further consider the possibility of the NTP in alternative regions. The new land stock is supplied to either Metro or Rural, instead of being uniformly distributed to all non-SMA regions. By doing so, we see the impact of the policy accounting for the TFP, amenities, and marginal production of factors, which is a function of the initial land stock.

Aggregate Output and Welfare Columns 3 and 4 of Table 6 show that the output and welfare changes are comparable to the leveling up experiment. Both measures are in the order of NTP in Metro, Leveling up, and NTP in Rural. It is mechanical that the leveling up serves as the median given the two polar cases of Metro and Rural. The welfare change differences are more dramatic because of lower amenities in Rural: NTP in Metro is 0.42%p higher than NTP in Rural.

Employment Shares, Housing Prices and Regional Output The two experiments are in the same ballpark at the aggregate level. Figure 16 reports that the regional consequences could differ. For example, in panel (b), the NTP-blessed regions attract populations from all the other regions, but the magnitude is much higher in Metro, by more than a factor of 3. The population loss of Rural in the NTP in Metro experiment is much larger than the counterpart

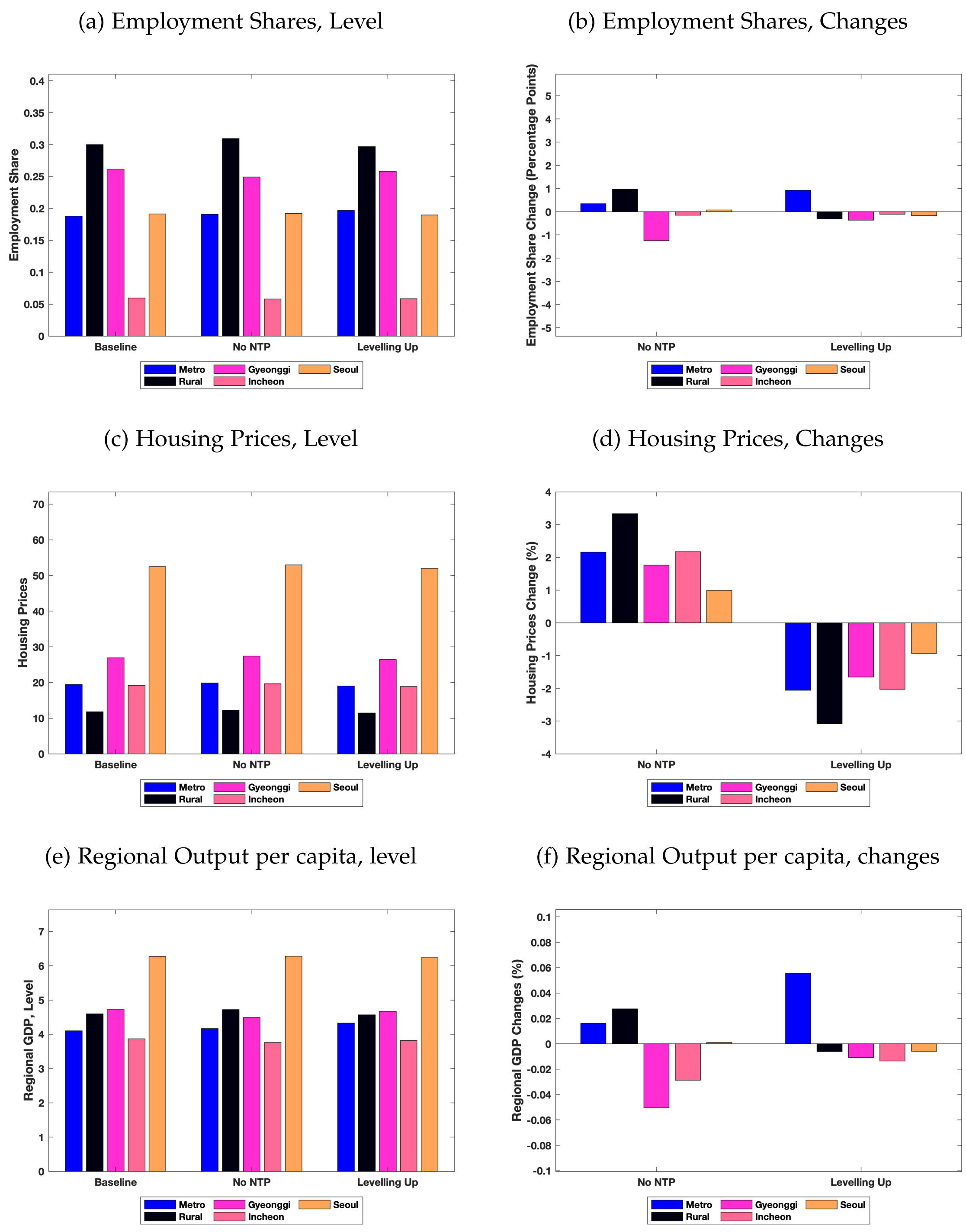


Figure 15: Active Land Supply: No NTP and Levelling Up the Country

of Metro in the NTP in Rural experiment. This discrepancy is partly due to the larger existing land stock in Rural: The supplied land is around 3.7% of total in Rural while 18.0% in Metro.

Still, the low TFP and amenities in Rural are another cause of this asymmetry.

Both experiments deliver lower housing prices in all regions as the leveling up experiment. Empowered by the additional land supply, neither Metro nor Rural ends up with a higher housing price in spite of population inflows. This implies that the land supply effect dominates housing demand expansion. Changes in the regional output per capita echo the change in employment shares in Panel (b).

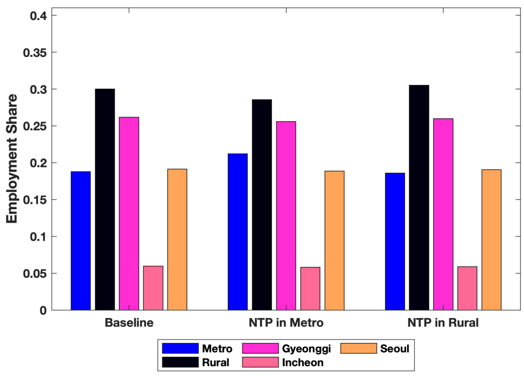
Closing the section, we emphasize that the experiments examining land-use regulation and active land supply are not directly comparable. Each experiment possesses a distinct internal consistency criterion: the "expanding existing cities" experiments are governed by the national usable land stock constraint; the "creating new cities" ones are governed by the total land supplied by NTP. Therefore, the results from the respective experiments on deregulating non-SMA and leveling up the country should not be compared to establish superiority of one to the other. Rather, they serve as separate explorations within the broader investigation of the relationship between land-use regulation and active land supply.

6 Conclusion

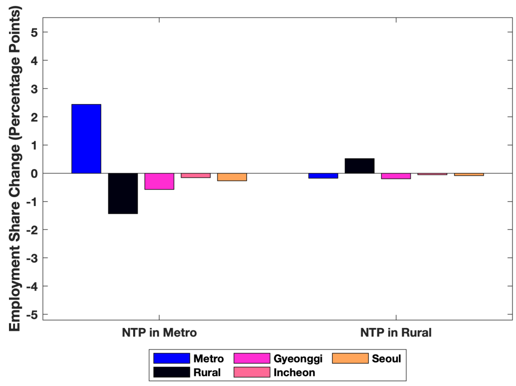
This paper studies land policies in South Korea by applying the general equilibrium spatial model developed by HOP. All regions are characterized by their TFP, amenities, land stock, and land-use restrictions. We first recover those parameters using the model equilibrium conditions, targeting the regional land price distribution of South Korea. The model closely matches the empirical distribution. For further model validation, we compare the model-inferred land-use restriction against two independent data counterparts: the regional-average floor area ratio and building coverage ratio. Simple linear regressions between the data and model show a tight correlation.

We conduct two sets of exploratory counterfactual experiments of land policy. The first set experiments with land-use restriction, given the fixed national stock of usable land. The results suggests that regulating the Seoul Metropolitan Area and deregulating the other regions may mitigate population concentration, but at the cost of universal housing price increase as much as 6% and a net loss in output and welfare around 1.3%. These results suggest that a simple approach of regulating concentrated regions and deregulating declining ones may bring a large cost at the aggregate level and not be successful to stabilize the housing market of the country. In other words, South Korea's land-use restriction to the SMA is already lenient and the economy is sufficiently utilizing the high TFP of the area. The result is opposite to the case of the United States, where superstar regions such as New York and California are "tarnished" and deregulating them would benefit the entire economy (Herkenhoff, Ohanian and Prescott, 2018) This is the international layer that we bring to the literature. While spatial

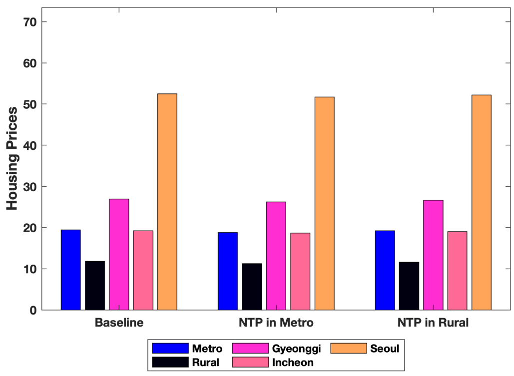
(a) Employment Shares, Level



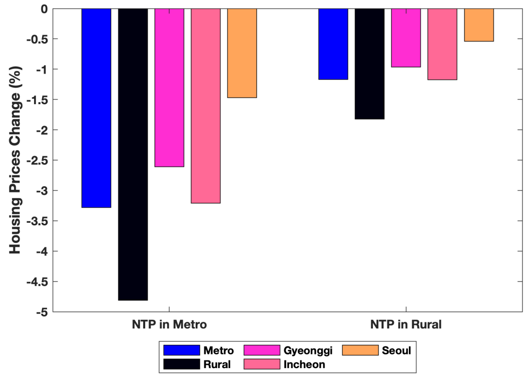
(b) Employment Shares, Changes



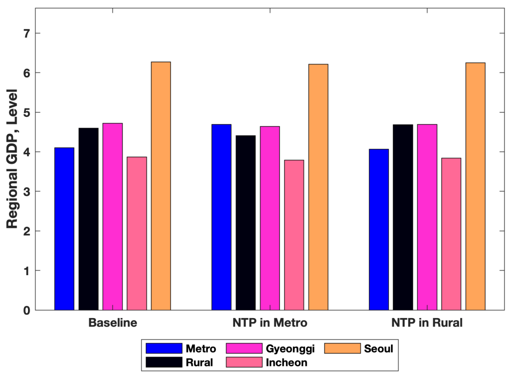
(c) Housing Prices, Level



(d) Housing Prices, Changes



(e) Regional Output per capita, level



(f) Regional Output per capita, changes

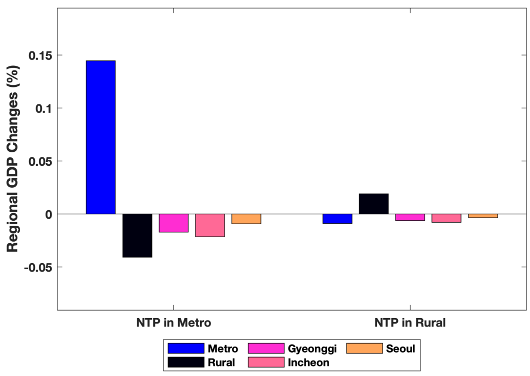


Figure 16: Active Labor Supply: New Town Project in Metro or Rural

concentration to superstar cities is common in developed economies, their land usage could be substantially different, thus policy should be country- or city-specific.

The second set of experiments are active land supply. We first conduct a cost-benefit analysis of the 2nd New Town Project in South Korea. The benefit, discounted sum of future real output gain amounting to 8% of annual real GDP, exceeds the cost, 4.05% of annual real GDP, by a factor of two. We compare a series of alternative regional land supply policies to the 2nd NTP. Our results indicate that supplying land to non-SMA regions, keeping the amount of spending equal, could have attained higher output, less spatial concentration, and lower housing prices. We provide the first quantitative analysis on this new type of policies, showing that this active land supply policy can affect the aggregate and regional economies significantly.

We conclude by emphasizing that there is no one clear-cut answer on how to execute the land policy efficiently. As our conunterfactuals on land-use restriction show, the effects of land use policies heavily depends on the characteristics of regional economies such as productivities and amenities. Lastly, how the trade-off between aggregate allocative efficiency gain and externalities coming from regional decline works can be different across countries. These tradeoffs imply that the optimal implementation of land-use policy demands thorough inspections of each regional economy.

We underscore that all our results are exploratory and indicate the issue deserves further comprehensive analysis. In future work, we incorporate agglomeration and mobility of workers with heterogeneous skills. The impact of land policy on regional policy could be more pronounced via housing market if it particularly deter or encourage of high-skilled workers to the region and agglomeration is in place.

A Calibrating the Land Share in Housing

To our best knowledge, there is no estimate of the land share in housing $(1-\xi)$ in South Korea. We pin this parameter down by targeting the land price distributions. Land price data from South Korea enabled us to apply this calibration strategy. The Cobb-Douglas technologies of final goods and housing and the land market clearing condition yields the following condition:

$$q_j = \frac{1}{x_j}\Big[(1-\xi)p_j n_j + (1-\theta-\chi)y_j\Big]. \tag{11}$$

Provided all the RHS variables x_j, yj, θ and χ, we can calculate a model-implied q_j. We pick $(1-\xi)$ to minimize the distance between the model-implied and observed q_j. Note that Equation (11) could be used for model validation if $(1-\xi)$ could be chosen either from literature or data.

B Algorithm for Counterfactual Simulations

In this section, we explain the algorithms calculating the counterfactual. Our benchmark economy is the steady state from the estimated (α, a, A), given the observed usable land stock x. These are the estimates that best explain the observed Korean regional data. We then alter either α or x, depending on experiment, and solve for new steady-states, keeping all others unchanged. We separate out the impact of changes in α or x by comparing the new steady states against the benchmark.

B.1 Guess on Equilibrium Quantities

Given the parameters, we make a guess on these three optimal policies.

- k^h_{jt}: capital for housing production
- k^y_{jt}: capital for consumption good production
- x^h_{jt}: land for housing production

Given the total quantity of the land in each region (x_v), the housing production function $h_{jt} = q(x^h_{jt}, k^h_{jt})$, and the labor-housing constraint, these three optimal policies imply the following equilibrium quantities:

- x^y_{jt}: land for consumption good production
- h_{jt}: housing quantity

- n_{jt}: labor allocation

Given all of these equilibrium quantities, we calculate the interest rate r which is the same for all regions. Once we calculate r, we can calculate:

- p_{jt}: Price of housing service
- q_{jt}: Rental rate of land
- w_{jt}: Wage
- π^y_{jt}: Consumption good producer profit
- π^h_{jt}: Housing construction firm profit

These objects allow us to calculate the aggregate consumption c_t from household's budget constraint.

B.2 Check Optimality Conditions

We check if the following optimality conditions hold given the obtained equilibrium quantities.

- Labor-Leisure Tradeoff

  : $w_{jt}u_{ct} + a_{jt} = -u_{n,jt} - p_{jt}u_{ct}$

- Land Allocation

  : Firm Production vs Housing Production

- Interest Rate

  : Euler Equation of Representative Households

We use MATLAB's `fsolve()` to verify that the optimal policies satisfy these optimal conditions for every region and repeat until we obtain the solution. The solution would be our counterfactual outcome.

C The 2nd New Town Project and Counterfactuals

In this section, we describe the 2nd New Town Project data used in Section 5.2. Our goal was to supply land to the non-SMA regions, keeping the policy-related expenditure fixed. It is seemingly straightforward to first calculate the total land supplied in SMA and then divide it by the number of non-SMA regions. However, this approach fails to address the case that the unit cost of land supply may differ across regions. If ignored, the counterfactual results could be taken as a lower bound.

Fortunately, we have additional information from the 2nd New Town Project. It had 15 subprojects. The SMA-related subprojects were 12 out of 15 and took nearly 90% of the total land supplied. On the other hand, there were three subprojects that took place in Daejeon and ChungCheongnam-do (D&C). We leverage their expenditure information to adjust the counterfactual unit costs. Table C.1 summarizes the cost per m^2, land supplied by use, and total expenditure.

Our measure of urban land is "Residential/Commercial (R/C)." The unit cost in the SMA is 798.8, approximately 150% of D&C, 536.3. Since the SMA R/C supply is 42.4, the counterfactual land supplied for the non-SMA is 63.1 = 42.4 $\times$ 1.49. The land supplied in Table 5.2 is a population-adjusted measure. The adjustment is not perfect but lets our experiments account for potential heterogeneity in the new city costs based on real-world information.

This calculation requires land supplied and expenditure by use. We have granular land data, but not expenditure data. Expenditure is available for the total only. We allocate the total expenditure to each category by using land supplied as a weight. For instance, in the SMA, the R/C land supplied is 35.7%. Thus, the R/C expenditure of 33,949.5 is a result of $94,920.6 \times 0.357$. Note that the land-supplied shares by use are similar across the SMA and D&C, which serve as a minimal justification of this approach.

The D&C New Town Project is *not* counted as a part of the 2nd NTP in the No NTP experiment. The land supplied is deducted only in the SMA; the D&C NTP land supplied is treated as if it were the existing land stock. This abstraction stems from the fact that our main goal is to analyze the impact of active land supply on the regional decline and spatial concentration of the SMA. Thus, the counterfactual land supply to the D&C would be an addition on top of the D&C NTP.

It's important to note that the D&C New Town Project was not included in the "No NTP" experiment as a part of the 2nd NTP. The land supplied in D&C was only deducted in the SMA, and the D&C NTP land supplied was treated as if it were part of the existing land stock. Thus, the counterfactual land supply to the D&C region would be in addition to the land already provided through the D&C New Town Project. This approach is motivated by the goal of the research, which is to analyze the impact of active land supply on regional decline and concentration to the SMA.

D More Results

D.1 Wages: Model-Predicted v. Observed

The model underpredicts wages, compared to per capital regional income. Still, the figure exhibits a strong linear relationship.

In one sense, this underprediction is mechanical. We are currently using per capita income

Table C.1: The 2nd New Town Project: Land supplied and Expenditure

Region	Cost per m2 (KRW)			Land Supplied (billion m^2)			Expenditure (billion KRW)		
	Total	(R/C)	(Ind/Inf)	Total	(R/C)	(Ind/Inf)	Total	(R/C)	(Ind/Inf)
SMA	798.8	800.9	797.6	118.8	42.4	76.4	94,920.6	33,949.5	60,971.1
				(100.0)	(35.7)	(64.3)	(100.0)	(35.8)	(64.2)
Daejeon and Chungceongnam	536.3	536.8	536.1	14.9	5.3	9.6	7,992.8	2,870.0	5,122.8
				(100.0)	(35.9)	(64.1)	(100.0)	(35.9)	(64.1)
SMA to D&C ratio	1.49	1.49	1.49						
Hypothetical non-SMA				177.0	63.1	113.8			

Percentages with respect to total in parentheses. "R/C" and "Ind/Inf" stands for "Residential/Commercial Use" and "Industrial/Infrastructure Use", respectively.

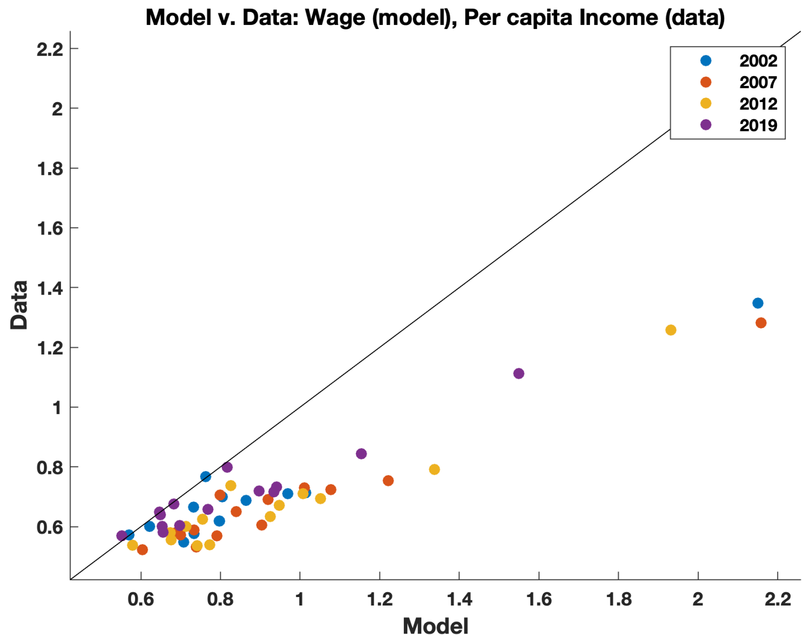


Figure D.1: Model v. Data: Wages

as our data counterpart because there are no reliable statistics of average wages at the regional level. Since per capita income includes capital and land as well, it is likely to be higher than wages. Therefore, the figure may understate the model performance systematically.

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